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ABSTRACT

This publication contains 317 multiple-choice chemistry test items related to topics covered in the Victorian (Australia) Year 12 chemistry course. It allows teachers access to a range of items suitable for diagnostic and achievement purposes, supplementing the ACER Chemistry Test Item Collection--Year 12 (CHEMTIC). The topics covered are: organic reaction mechanisms, analysis with a purpose, preparative chemistry, surface chemistry, carbon and silicon giant molecules, and from minerals to metals. (BW)

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ED206719

ACER CHEMTIC YEAR 12

ACER CHEMISTRY TEST ITEM COLLECTION

SUPPLEMENT

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ACER Chemistry Test Item Collection (ACER CHEMTIC YEAR 12)
SUPPLEMENT

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Introduction

This publication contains 317 multiple-choice chemistry items related to some of the Options in the Victorian Year 12 chemistry course. It is designed as a companion volume to the *ACER Chemistry Test Item Collection—Year 12* (*CHEMTIC*), which contains items related to the Core section of the course. Both volumes have been published in order to allow Victorian chemistry teachers access to a range of items suitable for diagnostic and achievement purposes, pending the publication of a larger item bank.

It is hoped that teachers will produce additional items of their own for this collection, and some notes on test construction and item writing techniques are included later. The ACER would be grateful if teachers forwarded their own *original* items on to the Council. It is intended that suitable items will be added to the item bank at a later date. Items should be forwarded to:

ACER Chemistry Item Bank,
PO Box 210,
Hawthorn,
Victoria 3122.

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The Chemistry Item Bank Project

During 1978 the VUSEB Chemistry Standing Committee suggested that the new Victorian Year 12 course would be assisted by the provision of a collection of test items. Later in 1978, the Victorian Education Department (Secondary Division) agreed to second a practising chemistry teacher to ACER to work on the preparation of a bank of chemistry items, related not only to the Victorian course, but to chemistry courses in each of the other States. The project was placed under the direction of a committee of management comprising:

Dr J. P. Keeves and Dr J. F. Izard—representing the ACER
Mr M. Cropley—representing the Victorian Institute of Secondary Education
Mr R. Fox—representing the VISE Chemistry Subject Committee
Dr I. Wilson—representing the Chemistry Education Association
Mr P. Martin was the secondee responsible for the day-to-day management of the project during 1979.
Dr C. Commons was the secondee responsible for the day-to-day management of the project during 1980.

Items which were written during 1979 have been published in the *ACER Chemistry Test Item Collection — Year 12* in order to provide Victorian teachers with an immediate source of items for the Core of the new Year 12 course, pending publication of the item bank. The current publication is intended to provide Victorian teachers with items related to the Options section of the course.

Most of the items included in this publication were written by practising chemistry teachers. After an initial editing, items were reviewed by panels of practising chemistry teachers. These reviewing panels had the task of correcting any mistakes in content, checking the plausibility of distractors, ensuring a uniformity of terminology, and imposing a consistent format which facilitates the answering of questions. Items which were found to have problems that could not be corrected were rejected. The remaining items were re-edited in the light of the reviewing panel's suggestions, and then assembled into trial tests.

Trial testing was conducted to provide empirical evidence on the performance of the items. It also provides basic statistical data, such as the percentage of trial students who responded correctly, as an aid for teachers when selecting specific items from the collection.

Trial testing was conducted in 47 Victorian secondary schools during September and October 1980. The trial tests were administered to a sample of students who had previously studied the topics for which the tests were designed. The average sample size was 125 with a range of 78 to 174 students. Generally items which had a discrimination index of 0·10 or greater were included in this publication. The discrimination index provides a measure of an item's capacity to differentiate more able students from less able students as determined from the total score on the test concerned. Items with a discrimination index of less than 0·10 have been included where it is believed they would be useful to teachers.

The following items were found to have a discrimination index of less than 0·10 from trial testing: **A-9, B-5, B-6, B-23, B-48, C-20, D-11, D-43, E-43, F-8.**

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Using the Collection

1 Uses for the Items

A Production of diagnostic tests

A diagnostic test is one which attempts to identify learning difficulties experienced by students and enables the provision of some form of assistance in overcoming the problems that are identified. Such tests should

(a) contain a comprehensive range of items measuring the objectives of the syllabus area that is being evaluated; and

(b) enable the provision of some form of feedback to the students after they have attempted the items.

The items in this collection have been constructed so that the choice of a particular distractor will allow the teacher to determine the nature of a student's error, and to advise the student of any appropriate remedial work necessary. Common errors could be discussed in class, and written explanations of the correct response (diagnostic aids) might be provided by the teacher. The format used in this publication enables teachers to select items which are most appropriate to the emphasis that they have given to various topics.

B Production of achievement tests

An achievement test is a test designed to measure a student's achievement in a particular syllabus area with a single score. Just as for a diagnostic test, it should contain a comprehensive range of items measuring the objectives of the syllabus area being evaluated. The degree of difficulty of an item can be approximately gauged by referring to the item facilities (giving the proportion of students who responded correctly to each item during trial testing). As the collection includes items with a wide range of facilities, it is possible to prepare tests which:

(a) discriminate very well between students in the more able section of the class (using items with a low facility),

(b) discriminate well between students in the weak section of the class (using items with a high facility); and

(c) spread the students over a wide range of marks (using items with a spread of facilities, with an average facility of about 50 per cent).

(Facility values may vary as emphasis on topics changes.)

The items in this collection alone may not be suitable for assessment of achievement, as some course objectives may be better examined using extended answer test items.

It should be noted that students may have access to this collection of test items.

C Models for constructing other items

This collection provides a range of item types which could be used as models for teachers who wish to construct their own items. If items from this collection are supplemented by teacher-written items, it is suggested that the supplementary items be consistent in style. Some rules for constructing multiple-choice items are outlined on page 4.

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2 Preparation of Tests

Test construction

In preparing a test, teachers should:

- Identify the particular syllabus areas that are to be evaluated.
- Select items which appear to evaluate these areas.
- Write items, where necessary, to provide an adequate coverage of the areas.
- Place the items in a logical order. Group items relevant to similar syllabus areas together. If possible, place the easier items early in the test, with the more difficult items towards the end of the test.
- Place items based on the same stimulus material on the one page.
- Ensure that one item does not supply the correct response for another item.
- Check that the items are not ambiguous and that each has a correct response listed.
- Prepare an answer key.
- Ask another teacher to work through the draft, to identify errors and omissions, as well as providing a check on the answer key.

3 Selecting an Item

To facilitate item identification, the items have been grouped in six units.[1]

Unit A:	Organic Reaction Mechanisms
Unit B:	Analysis with a Purpose
Unit C:	Preparative Chemistry
Unit D:	Surface Chemistry
Unit E:	Carbon and Silicon Giant Molecules
Unit F:	From Minerals to Metals

Answers and facilities for items are given beside the items in the left-hand margin. The following example illustrates this format.

A-22	Which one of the following species *cannot* act as a nucleophile?
77	
D	A HF B H_2O C NH_3 D CH_4 E Br^-

The facility of the item is 77 per cent—i.e. 77 per cent of the trial group of students answered this item correctly. The answer to the item is **D**.

Because of the restricted nature of each content area, items within a unit may overlap. Teachers choosing items should ensure that the answer for one item is not given in another. During the trial testing of items, most students completed an average of seven items per ten minutes.

4 Writing Additional Test Items

Multiple-choice items should incorporate the following points:

- The stem and each alternative must read grammatically when taken together.
- The problem posed or the question asked must be clearly set out in the stem.
- The whole item should be as brief as its proper presentation will allow.

[1] Victorian teachers will note that the six units correspond to six of the Options of the VISE syllabus.

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- To keep the alternatives brief, incorporate the major part of the idea in the stem. The following example illustrates this point:

Poor	*Better*
Chemistry is	Chemistry is a science that is concerned with
A a science that is concerned with the relationships and characteristics of matter.	**A** the relationships and characteristics of matter.
B a science that is concerned with the relationships of living organisms, etc.	**B** the relationships of living organisms etc.

- Avoid a negative stem where possible.

  If unavoidable, either

  (a) emphasize *not*, or

  (b) use: all of the following *except* one. Which one?

- All distractors should be equally attractive to the uninformed, yet the correct alternative must be unequivocally the best.

- Avoid using 'none of the above' as a distractor.
  A preferred alternative is,
  for example: **D** neither **A**, nor **B**, nor **C**.

- All alternatives must be homogeneous in idea and style.
  For example: Do not mix functions and structures.

- Words such as 'all', 'never', 'always', 'only' should not be used indiscriminately.

- Information presented in the stem must be factually correct.

- Distractors must be clearly incorrect, and not merely incomplete.

For a more comprehensive treatment of test construction and item writing, see:
Izard, J. F., *Construction and Analysis of Classroom Tests*, ACER 1977.

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UNIT A

Organic reaction mechanisms

A-1 75 **B**

The rate of a chemical reaction is usually expressed in the units

A sec^{-1}.
B $mol\ dm^{-3}\ sec^{-1}$.
C $mol\ sec^{-1}$.
D $mol^n\ dm^{-n}\ sec^{-n}$, where n is the order of the reaction.

A-2 78 **C**

For a second order reaction, increasing the concentration of all reactants by a factor of 3 will increase the rate of reaction by a factor of

A 3. **B** 6. **C** 9. **D** 27.

A-3 80 **E**

The order of the reaction $A + 2B \rightarrow C + D$ is

A 1.
B 2.
C 3.
D 5.
E determined only by experiment.

The next two items refer to the following information

The rate of the reaction $H_2 + NO \rightarrow H_2O + \frac{1}{2}N_2$ at 800 °C is given by the expression $Rate = 8{\cdot}8 \times 10^4\ [H_2]\ [NO]^2$.

A-4 68 **B**

The order of the reaction is

A 2. **B** 3. **C** 7. **D** $8{\cdot}8 \times 10^4$.

A-5 88 **D**

If the concentration of NO were doubled, the rate of the reaction would increase by a factor of

A $\frac{1}{4}$. **B** $\frac{1}{2}$. **C** 2. **D** 4.

A-6 52 **A**

The molecularity of a reaction is the

A number of particles involved in the slow step of a reaction.
B number of molecules participating in the reaction mechanism.
C change in the number of molecules during a chemical reaction.
D number of different species in the rate law.
E number of molecules produced in the rate determining step.

The next two items refer to the following information

The reaction between nitrogen oxide and hydrogen to form nitrogen and water is believed to occur by the mechanism

$$2NO + H_2 \xrightarrow{slow} N_2 + H_2O_2$$

$$H_2O_2 + H_2 \xrightarrow{fast} 2H_2O$$

A-7 28 **C**

The order of the reaction predicted by this mechanism is

A 1. **B** 2. **C** 3. **D** 4.

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A-8
33
B

The molecularity of the reaction is likely to be

A 2. B 3. C 4. D 5. E 9.

The next three items refer to the following information

The equation for the reaction between hydrogen peroxide and hydrogen iodide in acidic solution is

$$H_2O_2 + 2HI \rightarrow 2H_2O + I_2.$$

The rate equation for the reaction is

$$\textit{Rate of formation} \text{ of } I_2 = k[H_2O_2]\,[HI].$$

A-9
7
D

Equal volumes of 0·100 M solutions of the reactants were rapidly mixed.
The initial rate of reaction in mol dm^{-3} sec^{-1} was

A $(0{\cdot}100)k$.
B $(0{\cdot}100)^2k$.
C $(0{\cdot}100)^2k^2$.
D $(0{\cdot}050)^2k$.

A-10
78
C

If the number of moles of I_2 formed per second were x, the number of moles of HI consumed per second would be

A $\frac{x}{2}$. B x. C $2x$. D $4x$.

A-11
62
B

The order of reaction with respect to hydrogen peroxide is

A 0. B 1. C 2. D k.

A-12
54
D

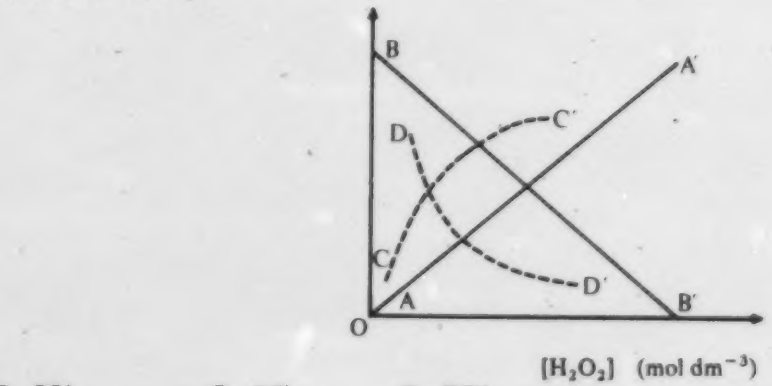
If the reaction $2X \rightarrow 2Z + Y$ is a first order process, then

A the reaction must be written $X \rightarrow Z + \frac{Y}{2}$.
B the rate of formation of products decreases by a factor of 8 if [X] is reduced by a factor of 4.
C the rate of formation of products decreases by a factor of 16 if [X] is reduced by a factor of 4.
D the rate of disappearance of X will double if [X] is doubled.
E the rate of disappearance of X will quadruple if [X] is doubled.

A-13
29
A

The graph below shows the variation of the initial rate of decomposition of H_2O_2 with initial concentration of various samples of H_2O_2 solution.

Which line indicates first order kinetics for the decomposition of hydrogen peroxide?



A AA′ B BB′ C CC′ D DD′

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A-14 86 **D**

The rate of formation of I_2 from the reaction

$$2NO_2^- + 2I^- + 4H^+ \rightarrow I_2 + 2NO + 2H_2O$$

is doubled when $[NO_2^-]$ is doubled, halved when $[I^-]$ is halved and increased by a factor of four when $[H^+]$ is doubled.

The rate law for this reaction is

A *Rate* $\propto [NO_2^-]^2 [I^-]^2 [H^+]^4$.

B *Rate* $\propto [NO_2^-] [I^-]^4 [H^+]^4$.

C *Rate* $\propto [H^+]^2$.

D *Rate* $\propto [NO_2^-] [I^-] [H^+]^2$.

A-15 67 **D**

The following data were obtained for the reaction

$$C_6H_5CHO + HCN \rightarrow C_6H_5CH(OH)CN$$

at 25 °C.

Experiment	Initial Concentration of C_6H_5CHO (mol dm^{-3})	Initial Concentration of HCN (mol dm^{-3})	Initial Rate of Formation of $C_6H_5CH(OH)CN$ (millimol dm^{-3} sec^{-1})
I	0·20	0·20	0·06
II	0·20	0·40	0·24
III	0·40	0·40	0·24

The rate of the reaction is proportional to

A $[C_6H_5CHO]$.

B [HCN].

C $[C_6H_5CHO]$ [HCN].

D $[HCN]^2$.

A-16 42 **C**

The reaction $3X + 2Y \rightarrow Z$ is believed to proceed by a mechanism involving a highly reactive compound, C.

Which of the following could be a mechanism for this reaction?

A $X + Y \rightarrow C + Z$
$C + X \rightarrow Z$

B $X \rightarrow 2C$
$C + Y \rightarrow Z$

C $X + Y \rightarrow C$
$2C + X \rightarrow Z$

D $X + Y \rightarrow 2C$
$2C + 2X \rightarrow Z$

A-17 76 **A**

The reaction

$$H_2O_2 + 2H_3O^+ + 2I^- \rightarrow 4H_2O + I_2$$

is believed to occur in the following stages:

$$H_2O_2 + I^- \xrightarrow{\text{slow}} H_2O + IO^-$$
$$IO^- + H_3O^+ \xrightarrow{\text{fast}} HIO + H_2O$$
$$HIO + H_3O^+ + I^- \xrightarrow{\text{fast}} 2H_2O + I_2$$

If this mechanism were correct, the rate of formation of water would be proportional to

A $[H_2O_2] [I^-]$.

B $[H_2O_2] [I^-]^2$.

C $[H_2O_2] [H_3O^+]^2 [I^-]^2$.

D $[IO^-] [H_3O^+]^2 [HIO] [I^-]$.

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A-18
67
A

It has been postulated that the following mechanism occurs in the reaction between HBr and O_2.

I $HBr + O_2 \rightarrow HOOBr$

II $HOOBr + HBr \rightarrow 2HOBr$

III $HOBr + HBr \rightarrow H_2O + Br_2$

The reaction is found experimentally to be first order with respect to both HBr and O_2. The rate of the reaction is probably determined by

A step I.
B step II.
C step III.
D two of the above.

The next two items refer to the following information

The rate of substitution of Br for OH in 2-methylpropan-2-ol, according to the equation

$$(CH_3)_3\,COH + H^+ + Br^- \rightarrow (CH_3)_3\,CBr + H_2O$$

follows the rate law

$$\frac{d[(CH_3)_3\,CBr]}{dt} = k[H^+]\,[(CH_3)_3\,COH],$$

where $\frac{d[(CH_3)_3\,CBr]}{dt}$ signifies the rate of formation of $(CH_3)_3\,CBr$.

A-19
58
D

The rate of reaction would increase if

A F^- were substituted for Br^-.
B water were added.
C $[Br^-]$ were doubled.
D more HBr gas were bubbled into the mixture.

A-20
49
A

A mechanism consistent with the information given above is

A i $(CH_3)_3\,COH + H^+ \xrightarrow{slow} (CH_3)_3\,C^+ + H_2O$
ii $(CH_3)_3\,C^+ + Br^- \xrightarrow{fast} (CH_3)_3\,CBr$.

B i $(CH_3)_3\,COH + H^+ \xrightarrow{fast} (CH_3)_3\,C^+ + H_2O$
ii $(CH_3)_3\,C^+ + Br^- \xrightarrow{slow} (CH_3)_3\,CBr$.

C $(CH_3)_3\,COH + H^+ + Br^- \xrightarrow{slow} (CH_3)_3\,CBr + H_2O$.

D i $(CH_3)_3\,COH + H^+ \xrightarrow{fast} (CH_3)_3\,COH_2^+$
ii $(CH_3)_3\,COH_2^+ + Br^- \xrightarrow{slow} (CH_3)_3\,CBr + H_2O$.

E i $(CH_3)_3\,COH + Br^- \xrightarrow{slow} (CH_3)_3\,CBr + OH^-$
ii $OH^- + H^+ \xrightarrow{fast} H_2O$.

A-21
70
A

In the reaction sequence

$$HNO_3 + 2H_2SO_4 \rightarrow \underline{NO_2^+} + H_3O^+ + 2HSO_4^{2-}$$

$$\underline{NO_2^+} + C_6H_6 \rightarrow C_6H_5NO_2 + H^+$$

the underlined species would be best described as a (an)

A electrophile.
B nucleophile.
C radical.
D carbonium ion.

A-22
77
D

Which one of the following species *cannot* act as a nucleophile?

A HF B H_2O C NH_3 D CH_4 E Br^-

A-23
77
C

The order of **decreasing** nucleophilic reactivity of the three species, H_3O^+, H_2O and OH^-, is

A $H_3O^+ > H_2O > OH^-$.
B $H_2O > OH^- > H_3O^+$.
C $OH^- > H_2O > H_3O^+$.
D $OH^- > H_3O^+ > H_2O$.
E $H_2O > H_3O^+ > OH^-$.

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A-24 67 **C**

CH_3CH_2I reacts with CH_3CH_2ONa in CH_3CH_2OH to produce $CH_3CH_2OCH_2CH_3$ and NaI. The nucleophile in this reaction is probably

A CH_3CH_2I. **B** I^-. **C** $CH_3CH_2O^-$. **D** CH_3CH_2OH. **E** $CH_3CH_2^+$.

A-25 42 **D**

Bromobenzene is formed when benzene and bromine react in the presence of aluminium bromide. It is believed that in the first step of the reaction Br^+ is generated by the process

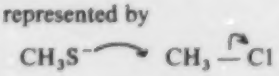
$$AlBr_3 + Br_2 \rightleftharpoons AlBr_4^- + Br^+.$$

The mechanism of the reaction step in which bromobenzene is formed is therefore likely to be

A S_N1. **B** S_N2. **C** addition. **D** electrophilic substitution. **E** radical substitution.

A-26 59 **B**

The attack of CH_3S^- on CH_3Cl is represented by



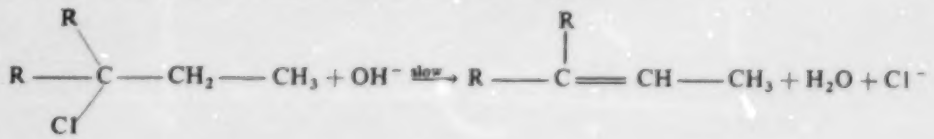
This mechanism is best classified as

A S_N1. **B** S_N2. **C** addition. **D** initiation. **E** condensation.

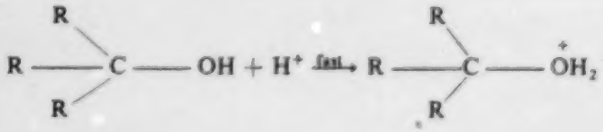
A-27 30 **C**

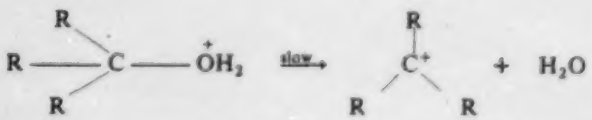
Which of the following mechanisms may be classified as S_N2?

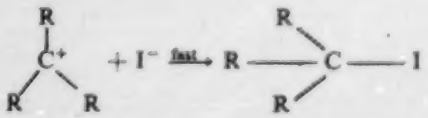
A



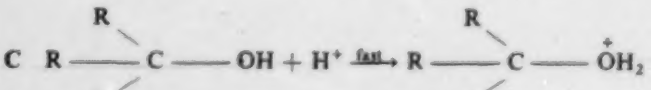
B

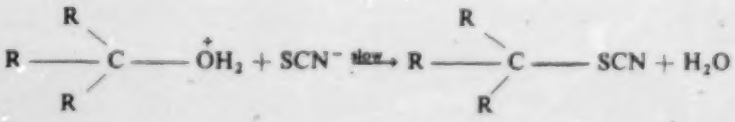






C





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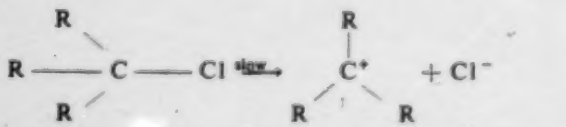

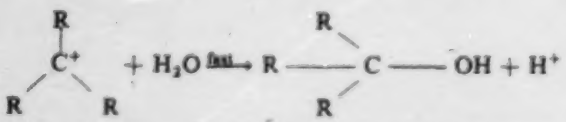

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A-28
86
B

In an experiment, the rate law for the formation of 2-hydroxypropane from 2-bromopropane and sodium hydroxide in a particular solvent was found to be

$$Rate = 4{\cdot}7 \times 10^{-5}\,[(CH_3)_2CHBr]\,[OH^-] + 0{\cdot}24 \times 10^{-5}\,[(CH_3)_2CHBr].$$

Which of the following statements is most likely to be correct?

A The rate law would be almost identical in other solvents.

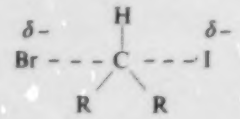
B The reaction was proceeding by both unimolecular and bimolecular mechanisms.

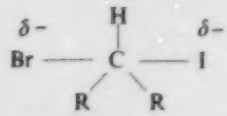
C The rate law indicates third order kinetics.

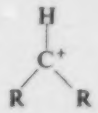
D An electrophilic substitution reaction was occurring in preference to a nucleophilic substitution reaction.

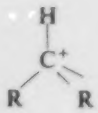
A-29
69
C

Which of the following best represents the structure of a species formed in an S_N1 reaction between an alkyl bromide, R_2CHBr, and the I^- ion?

A 

B 

C 

D 

A-30
79
B

The reaction between a bromoalkane and hydroxide ion can be represented by the equation

$$RBr + OH^- \rightarrow ROH + Br^-.$$

It is found experimentally that the reaction rate for a particular reaction is proportional to the concentration of RBr, but is independent of the concentration of OH^-. Which of the following statements is **inconsistent** with these observations?

A The reaction shows first order.

B The attack of R^+ by OH^- is the rate determining step.

C The breakage of the R-Br bond is a slow reaction.

D The rate determining step is unimolecular.

E The R-Br bond breaks before the OH^- attacks R.

A-31
44
C

The alkyl iodide $(CH_3)_3CI$ was warmed with an equimolar quantity of a radioactive form of sodium iodide, NaI*, in ethanol.

Isolation of the organic material from the equilibrium mixture yields

A $(CH_3)_3CI$.

B $(CH_3)_3CI^*$.

C equal amounts of $(CH_3)_3CI$ and $(CH_3)_3CI^*$.

D more of $(CH_3)_3CI$ than $(CH_3)_3CI^*$.

E more of $(CH_3)_3CI^*$ than $(CH_3)_3CI$.

A-32
89
B

Which of the following carbonium ions has the greatest stability?

A $(CH_3)_2CH^+$

B $(CH_3)_3C^+$

C $CH_3CH_2^+$

D CH_3^+

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A-33
80
A

In which of the following lists are carbonium ions given in increasing order of stability?

A $CH_3CH_2^+ < (CH_3)_2CH^+ < (CH_3)_3C^+$
B $(CH_3)_2CH^+ < CH_3CH_2^+ < (CH_3)_3C^+$
C $(CH_3)_3C^+ < (CH_3)_2CH^+ < CH_3CH_2^+$
D $(CH_3)_3C^+ < CH_3CH_2^+ < (CH_3)_2CH^+$

A-34
82
D

Which of the following is likely to react most rapidly by an S_N2 mechanism?

A CH_3CH_2Br
B $CH_3CHBrCH_2CH_3$
C $(CH_3CH_2)_3CBr$
D CH_3Br

A-35
83
C

Which of the following compounds has the greatest steric hindrance to attack by a nucleophile?

A CH_3Br
B $CH_3CH_2CH_2Br$
C $(CH_3CH_2)_2CHBr$
D $(CH_3)_2CHBr$

A-36
70
C

In order to facilitate 2-chloropropane, $CH_3CHClCH_3$, to react with a nucleophile by an S_N2 mechanism, it would be best to

A increase the temperature.
B use a small amount of nucleophile.
C use a strong nucleophile.
D use a very polar solvent.

A-37
72
D

Which of the following solvents would be most likely to facilitate the reaction of OH^- with $(CH_3)_2CHBr$ by the S_N1 mechanism (assuming that the reactants are soluble in each case)?

A CH_3OH
B propanone (acetone)
C CCl_4
D H_2O
E $CHCl_3$

A-38
53
E

Which of the following lists contains the solvents water, carbon tetrachloride, acetone and ethanol in increasing order of their ability to promote the S_N1 mechanism?

A water, carbon tetrachloride, acetone, ethanol
B ethanol, acetone, carbon tetrachloride, water
C carbon tetrachloride, acetone, water, ethanol
D ethanol, carbon tetrachloride, water, acetone
E carbon tetrachloride, acetone, ethanol, water

A-39
52
C

It is desired to react I^- and CH_3Br by the S_N2 mechanism. Which of the following solvents would be most likely to facilitate the desired mechanism (assuming that the reactants are soluble in each case)?

A CH_3OH
B $CHCl_3$
C CCl_4
D H_2O

A-40
50
C

Which of the following bromoalkanes would be expected to undergo **most** rapid nucleophilic substitution on hydrolysis with pure water?

A CH_3CH_2Br
B $CH_3CH_2CHBrCH_2CH_3$
C $(CH_3)_3CBr$
D CH_3Br

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A-41 31 **C**

Nucleophilic attack by ammonia on 2-bromo-2-methylpropane, $(CH_3)_3CBr$, in a suitable solvent occurs by an S_N1 mechanism.

If the ammonia were replaced by water, the

A reaction rate would increase.

B reaction rate would decrease.

C reaction rate would be almost unaffected.

D reaction would stop.

A-42 47 **C**

$(CH_3)_3CCl$ reacts with H_2O in ethanol forming $(CH_3)_3COH$.
If OH^- were used instead of H_2O, the rate of the reaction would be

A much faster.

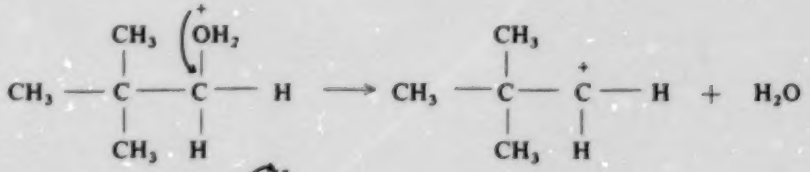
B much slower.

C about the same.

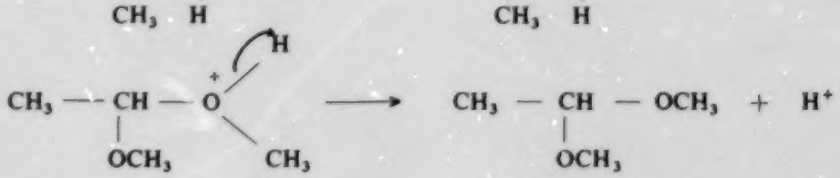
A-43 57 **D**

Which of the following equations correctly depicts the use of a curved arrow to signify the shift of a pair of electrons?

A



B



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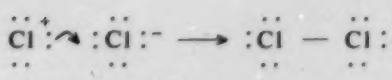

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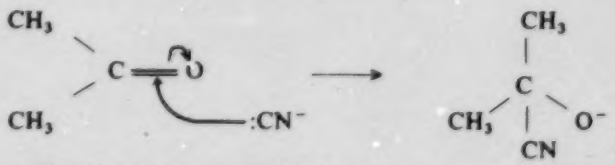

A-44 68 **B**

Free radicals are best described as

A negatively charged atoms or groups of atoms with one or more extra electrons.

B neutral atoms or groups of atoms with one or more unpaired electrons.

C positively charged atoms or groups of atoms which have lost one or more electrons.

D isolated groups of atoms which are negatively charged.

A-45 43 **D**

Which of the following is a free radical?

A NO_2^+ **B** Cl_2 **C** Br^- **D** H

A-46 39 **B**

In the absence of ultraviolet light, the reaction between chlorine and ethylene, CH_2CH_2, is likely to be

A a radical reaction.

B an addition reaction.

C an electrophilic substitution.

D a nucleophilic substitution.

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A-47
33
B

When chlorine is passed through warm benzene in sunlight a reaction occurs to produce $C_6H_6Cl_6$. Chlorine and warm benzene do not react in the absence of sunlight or ultraviolet light.

From these facts we conclude that the species attacking the benzene ring is probably

A a Cl_2 molecule
B a Cl atom.
C a Cl^- ion.
D a Cl^+ ion.

A-48
69
B

It has been proposed that the reaction occurring between chlorine and methane proceeds via a chain mechanism involving free radicals.

Which one of the following is a possible chain propagating step?

A $CH_3^\bullet + Cl^\bullet \rightarrow CH_3Cl$
B $CH_3^\bullet + Cl_2 \rightarrow CH_3Cl + Cl^\bullet$
C $CH_3^\bullet + CH_3^\bullet \rightarrow CH_3CH_3$
D $Cl_2 \rightarrow 2Cl^\bullet$

A-49
84
C

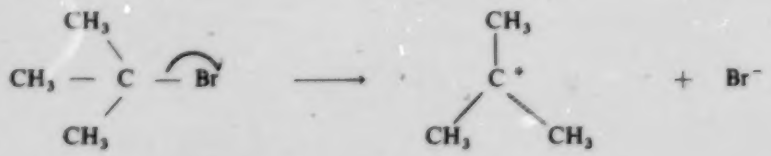
The step $CH_3^\bullet + Cl^\bullet \rightarrow CH_3Cl$ in the reaction between methane and chlorine is called a

A propagating step.
B initiating step.
C terminating step.
D rate determining step.

A-50
21
B

Which of the following equations correctly depicts the use of a single-headed curved arrow to represent the shift of an electron?

A



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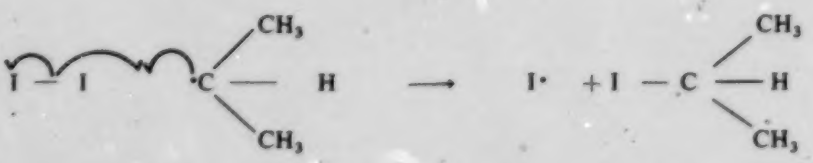

C.

D

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UNIT B

Analysis with a purpose

Unit B

B-1 82 D

A characteristic of random errors is that

A they are caused by incorrect calibration of apparatus.
B they are caused by permanent faults in apparatus.
C the error is the same for any measurement taken at random.
D their effect is reduced by calculating the mean of several measurements.

B-2 89 C

Two students attempted to determine the mass of water delivered by a pipette. Both students performed the determination four times. Their results, in gram, are listed below.

Student A: 24·96, 25·01, 25·10, 24·92.

Student B: 25·30, 25·32, 25·31, 25·34.

If the pipette actually delivers 25·00 g of water, which of the following statements is correct?

A Student A's results suggest systematic errors were present and have a higher precision.
B Student A's results suggest random errors were present and have a higher precision.
C Student B's results suggest systematic errors were present and have a higher precision.
D Student B's results suggest random errors were present and have a lower precision.

B-3 83 C

Four students (W, X, Y and Z) were asked to determine the mass of a watch glass. Each student weighed the watch glass four times.

Their results are given below.

Student	Mass of watch glass (in g)			
W	18·8	18·6	19·2	18·8
X	20·1	18·9	18·5	18·0
Y	19·3	19·5	19·4	19·5
Z	17·7	19·1	18·8	19·2

The mass of the watch glass was $(18{\cdot}90 \pm 0{\cdot}01)$ g.

Which student's results show evidence of a systematic error?

A W **B** X **C** Y **D** Z

B-4 33 A

The amount of NaCl in 0·003 dm^3 of a 0·0200 M NaCl solution is best expressed in standard form as

A 6×10^{-5} mol.
B $6{\cdot}0 \times 10^{-5}$ mol.
C $6{\cdot}00 \times 10^{-5}$ mol.
D $6{\cdot}000 \times 10^{-5}$ mol.
E $6{\cdot}0000 \times 10^{-5}$ mol.

B-5 21 C

A solution of volume 2·0 dm^3 contains 0·426 mol of Na_2CO_3. The concentration of the sodium carbonate is best expressed as

A 0·2130 M. **B** 0·213 M. **C** 0·21 M. **D** 0·2 M.

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B-6
4
D

The uncertainty in each reading of a particular burette scale is quoted as $\pm 0{\cdot}02\ cm^3$. The percentage uncertainty in a volume of $40{\cdot}00\ cm^3$ delivered by the burette is

A 0·0005. B 0·001. C 0·05. D 0·1.

B-7
84
C

If $(20 \pm 2)\ cm^3$ of water were removed from a flask containing $(100 \pm 10)\ cm^3$ of water, the volume of liquid remaining would be

A $(80 \pm 8)\ cm^3$.
B $(80 \pm 10)\ cm^3$.
C $(80 \pm 12)\ cm^3$.
D $(80 \pm 16)\ cm^3$.

B-8
82
D

A flask of concentrated sodium hydroxide solution has a mass of $(100{\cdot}0 \pm 0{\cdot}4)$ g. After carbon dioxide gas was bubbled through the solution the mass of the flask was $(160{\cdot}0 \pm 0{\cdot}4)$ g.

The mass of carbon dioxide absorbed by the solution is best stated as

A $(60{\cdot}0 \pm 0{\cdot}0)$ g.
B $(60{\cdot}0 \pm 0{\cdot}1)$ g.
C $(60{\cdot}0 \pm 0{\cdot}4)$ g.
D $(60{\cdot}0 \pm 0{\cdot}8)$ g.

B-9
42
C

The amount of NaOH in $(50{\cdot}0 \pm 0{\cdot}2)\ cm^3$ of a solution of concentration $(1{\cdot}000 \pm 0{\cdot}002)$ M is

A $(0{\cdot}050 \pm 0{\cdot}202)$ mol.
B $(0{\cdot}0500 \pm 0{\cdot}0001)$ mol.
C $(0{\cdot}0500 \pm 0{\cdot}0003)$ mol.
D $(0{\cdot}0500 \pm 0{\cdot}0006)$ mol.

B-10
38
A

$(500 \pm 5)\ cm^3$ of a solution contains (50 ± 2) g of sodium chloride.

The uncertainty in the concentration of the solution, in $g\ cm^{-3}$, is

A $\pm 0{\cdot}005$. B $\pm 0{\cdot}1$. C ± 5. D ± 7.

B-11
53
B

The uncertainty in the volume of a $250\ cm^3$ standard flask is approximately

A $2{\cdot}5\ cm^3$. B $0{\cdot}25\ cm^3$. C $0{\cdot}025\ cm^3$. D $0{\cdot}010\ cm^3$.

B-12
68
D

The volume delivered by a $20\ cm^3$ standard pipette is approximately

A $20 \pm 1\ cm^3$.
B $20{\cdot}0 \pm 0{\cdot}1\ cm^3$.
C $20{\cdot}0 \pm 0{\cdot}2\ cm^3$.
D $20{\cdot}00 \pm 0{\cdot}01\ cm^3$.

The next three items refer to the following information

A volume of NaOH solution was pipetted into a conical flask and a few drops of phenolphthalein indicator was added. A burette was filled with standard HCl solution, and the base was titrated with the acid. This procedure was repeated three times.

The concentration of the NaOH solution was calculated on the basis of the titres obtained.

B-13
51
A

Which one of the following factors could be responsible for systematic errors in the analysis?

A The concentration quoted for the standard HCl solution was incorrect.
B Burette readings were estimated to the nearest tenth of the smallest scale division.
C The tap of the burette leaked during one of the titrations.
D A small quantity of base remained in the pipette tip each time it was used.

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B-14 66 C

If the pipette were always rinsed with distilled water before being filled with base, what effect would this have on the concentration calculated for the NaOH solution?

A The calculated concentration should be equal to the actual concentration.
B The calculated concentration should be higher than the actual concentration.
C The calculated concentration should be lower than the actual concentration.

B-15 57 A

If the conical flask were always rinsed with distilled water before being filled with base, what effect would this have on the concentration calculated for the NaOH solution?

A The calculated concentration should be equal to the actual concentration.
B The calculated concentration should be higher than the actual concentration.
C The calculated concentration should be lower than the actual concentration.

B-16 65 A

Which **one or more** of the following would be classified as quantitative analysis?

A determination of the percentage of iron in a piece of sandstone
B determination of the presence of sodium in a sample of water
C separation of a mixture by thin layer chromatography
D identification of a liquid by absorption spectroscopy
E isolation of chlorophyll from leaves by column chromatography

B-17 87 A

A standard solution is a solution which

A has an accurately known concentration.
B does not deteriorate or react with the atmosphere.
C is prepared using a volumetric flask.
D is prepared from an accurately measured mass of solute.

B-18 63 E

Which one of the following sets of apparatus is normally used in the preparation of a solution of a primary standard?

A analytical balance and pipette
B analytical balance and burette
C volumetric flask and pipette
D volumetric flask and burette
E volumetric flask and analytical balance

B-19 42 B

In order to prepare a standard 0·100 M solution of sodium carbonate (M_r = 106), 10·6 g of anhydrous sodium carbonate should be dissolved in

A 1000 cm^3 of water.
B enough water to make 1000 cm^3 of solution.
C 1000 g of water.
D enough water to make 1000 g of solution.

B-20 32 A,C

Sodium hydroxide pellets would not be suitable for use as a primary standard in the standardization of hydrochloric acid for **one or more** of the following reasons. Which one (s)?

A The pellets absorb moisture from the air.
B The endpoint for this titration is indistinct.
C The pellets react with carbon dioxide in the air.
D The pellets deteriorate in the presence of oxygen.
E The end point for this titration is not the same as the equivalence point.

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B-21 61 **B**

The end point in an acid-base titration is the point when

A the solution is neutral.
B the indicator changes colour.
C equal volumes of reactants have been mixed.
D reactants have been mixed in the appropriate stoichiometric ratio.

B-22 46 **D**

0·80 g of sodium hydroxide ($M_r = 40$) was weighed from a bottle and dissolved in 15·0 cm^3 of water. This solution was then titrated with a solution of 1·0 M nitric acid. The indicator changed colour when 17·5 cm^3 of the nitric acid solution was added, instead of the expected 20·0 cm^3. This discrepancy could be explained *if*

A more than 15·0 cm^3 of water was added to the sodium hydroxide.
B the equivalence point of the reaction was reached before the end point.
C the actual mass of sodium hydroxide used was more than 0·80 g.
D the sodium hydroxide in the bottle had absorbed water from the air before weighing.
E the concentration of the nitric acid solution was less than 1·0 M.

B-23 24 **D**

A sample of sand was known to have an iron content of 0·16 %. A student attempted to analyse the sample by extraction of the iron with an acid solution, conversion to Fe^{2+} and titration with standard acidified $KMnO_4$ solution. From the recorded titre, he calculated the iron content to be 0·13 %.

Which of the following could account for the incorrect result?

A The mass of the sample of sand was greater than measured by the chemist.
B The $KMnO_4$ solution used by the chemist had partially decomposed since its standardization.
C Another metal ion present in the sand also reacted with the $KMnO_4$ solution.
D The volume of $KMnO_4$ used in the titration was larger than recorded by the chemist.

B-24 86 **A**

In order to perform a successful gravimetric analysis of the percentage of copper in a mass of copper ore, it should **not** be necessary to

A use an indicator to determine an equivalence point.
B weigh a sample of the ore accurately.
C dissolve the copper in the ore in a solvent.
D collect a precipitate by filtration.

B-25 71 **D**

Which one of the following pieces of apparatus **must** be used in an accurate gravimetric analysis?

A chromatographic column
B volumetric flask
C burette
D analytical balance
E filter funnel

B-26 82 **B**

Which of the following procedures is likely to be involved in the gravimetric analysis of iron in a steel sample?

A titration of Fe^{2+} ions in acid solution with a standard solution of $KMnO_4$
B measurement of the mass of Fe_2O_3 residue obtained by dehydration of a precipitate of $Fe(OH)_3$
C determination of the colour intensity of a solution of $FeSCN^{2+}$
D separation of Fe^{2+} ions from Fe^{3+} ions on a chromatography column using an acid as eluent

B-27 82 **B,C**

The moisture content of a wool consignment is obtained by measuring the mass of a sample of the wool, dehydrating by heating in an oven and then subsequently measuring the dried mass. The moisture content is then assessed by mass difference. This technique is an example of **one or more** of the following types of analysis.

Which one(s)?

A volumetric analysis
B quantitative analysis
C gravimetric analysis
D qualitative analysis

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B-28
68
C

Which of the following measurements would be most useful in identifying an unknown component separated by a gas chromatograph?

A distance moved by the component through the stationary phase
B width of the component's peak on the recorder chart
C time taken for the component to pass through the instrument
D height of the component's peak on the recorder chart

B-29
52
C

Which of the following statements about the states of substances **within** a gas chromatograph is correct?

A The test sample only must be in the gaseous state.
B The mobile phase only must be in the gaseous state.
C The test sample and the mobile phase must be in the gaseous state.
D The test sample and the stationary phase must be in the gaseous state.
E The test sample, the mobile phase and the stationary phase must be in the gaseous state.

B-30
74
A

A petrol company finds that a rival product gives better test results in car engines. They suspect that the other company is adding methanol to its petrol, and request a chemist to test for this.

Which of the following analytical techniques would be the most suitable in this case?

A gas chromatography
B column chromatography
C paper chromatography
D thin layer chromatography
E atomic absorption spectroscopy

B-31
88
A

The most sensitive chromatographic technique is

A gas chromatography.
B column chromatography.
C paper chromatography.
D thin layer chromatography.

B-32
67
A

Which of the following substances could be used as the eluent in column chromatography?

A ethanol
B alumina
C nitrogen
D paper

B-33
60
B

When a solution containing substance X is placed on a chromatography column, the rate at which X moves down the column is different from that of the solvent.

The ratio of these rates is most directly related to the

A density of packing of the stationary phase.
B relative attractions of X and the solvent for the stationary phase.
C relative solubilities of X and the stationary phase in the solvent.
D rate of flow of the solvent through the chromatography column.

B-34
85
B

A certain Asian herb is found to be an effective treatment for a serious illness. A drug company extracts the active chemical in impure form.

Which of the following techniques would be most suitable for obtaining the pure chemical in large amounts?

A gas chromatography
B column chromatography
C paper chromatography
D thin layer chromatography

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B-35 Paper chromatography would be **most** suitable for

86

C

A detecting the presence of trace quantities of benzene in methylated spirits.

B extracting a large quantity of aspirin from tablets containing aspirin and phenacetin.

C separating the compounds present in a black dye.

D separating the clay particles from a sample of river water.

B-36 Which one of the following procedures is **least** likely to affect an analysis of a mixture using paper chromatography?

71

C

A leaving the paper in contact with the solvent for a very long period

B handling the paper before the chromatogram is run

C placing a pencil mark at the starting point of the mixture

D placing the paper in an open dish of solvent

B-37 Paper chromatography was used to separate the pigments in a plant leaf. A spot of the pigments was placed on a sheet of chromatography paper and the chromatograph was run inside a closed jar which was partly filled with ethanol.

76

B

The mobile phase in this instance is the

A pigments.

B ethanol.

C paper.

D ethanol vapour in the jar.

B-38 A chemist extracts a very small amount of colouring material from a rare flower. Which of the following analytical techniques would be most appropriate for determining whether the material is composed of a mixture of several pigments?

71

C

A gravimetric analysis

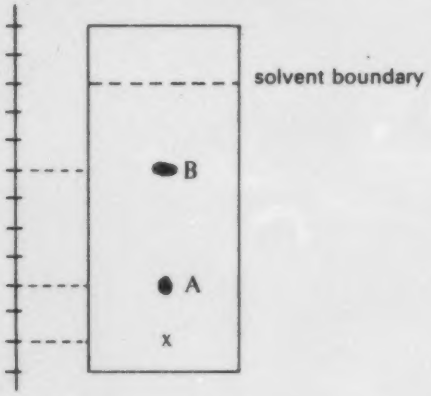
B column chromatography

C thin layer chromatography

D atomic absorption spectroscopy

The next two items refer to the following information

The diagram below represents a thin layer chromatography plate which has been developed by standing the plate in a trough of solvent. Spots of a sample, containing components A and B, were originally placed at X.



B-39 Compared to component A, component B is absorbed

66

D

A more strongly onto the stationary phase, and has a larger R_f value.

B less strongly onto the stationary phase, and has a smaller R_f value.

C more strongly onto the stationary phase, and has a smaller R_f value.

D less strongly onto the stationary phase, and has a larger R_f value.

B-40 The value of R_f (B) is

63

A

A $\frac{2}{3}$. B $\frac{3}{2}$. C 3. D $\frac{1}{3}$. E $\frac{6}{10}$. F $\frac{10}{6}$.

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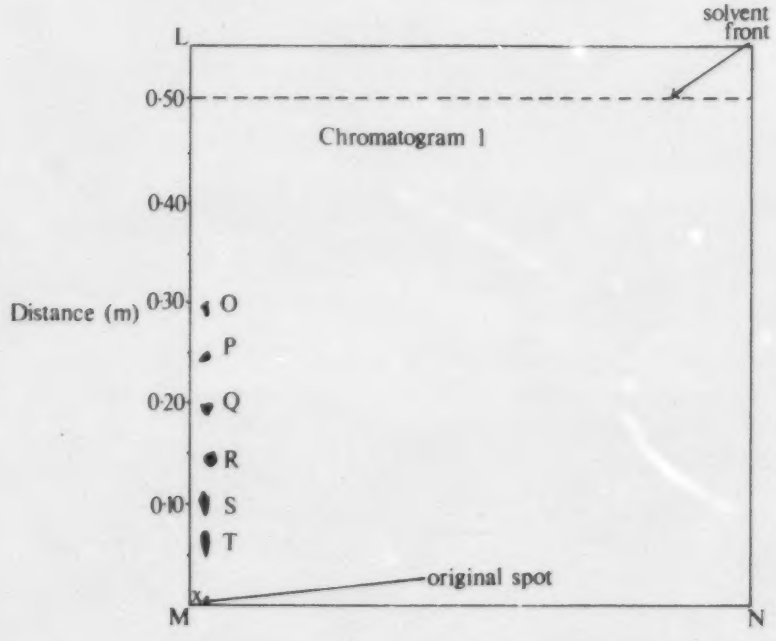
The next five items refer to the following information

The table below lists some amino acids, together with their R_f values in two solvents.

Amino Acid	R_f Solvent 1	R_f Solvent 2	Amino Acid	R_f Solvent 1	R_f Solvent 2
alanine	0·24	0·55	lysine	0·12	0·55
2-aminobutyric acid	0·28	0·58	β-phenylamine	0·50	0·86
arginine	0·13	0·60	proline	0·39	0·88
glutamic acid	0·25	0·33	serine	0·19	0·34
glycine	0·20	0·40	taurine	0·12	0·33
hydroxyproline	0·21	0·67	threonine	0·21	0·49
isoleucine	0·57	0·81	tyrosine	0·38	0·62
leucine	0·58	0·82	valine	0·40	0·74

A small sample of a mixture of some of these amino acids is placed at the corner of a square piece of chromatography paper, and a chromatogram is developed using solvent 1. In the chromatogram below, L, M, N refer to the corners of the paper, O, P, Q, R, S and T to the spots on the chromatogram.



B-41 The R_f value for spot R using solvent 1 is approximately

79

B **A** 0·14. **B** 0·28. **C** 0·36. **D** 0·72.

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B-42 The substance in spot O is

52

C

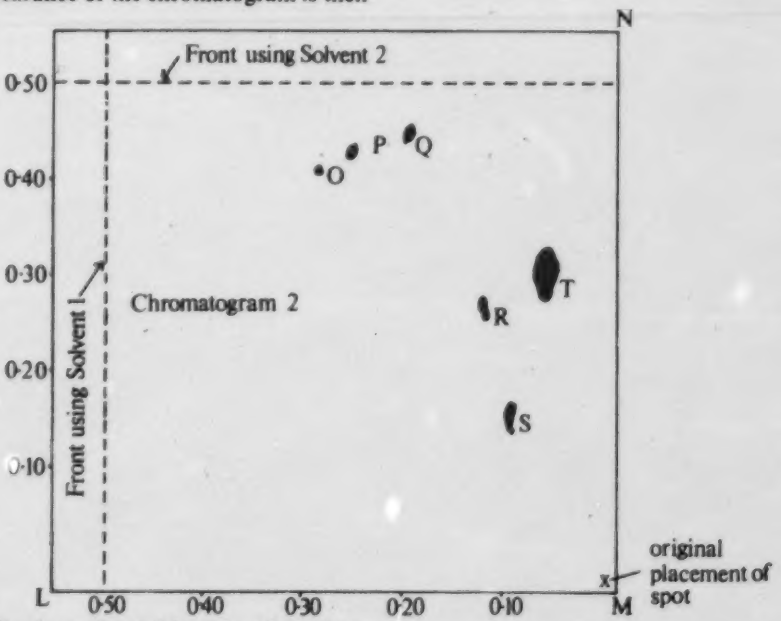
A 2-aminobutyric acid only.

B leucine only.

C isoleucine and/or leucine.

D some other combination of the amino acids listed in **A** to **C**.

The chromatogram is now rotated so that the edge LM is in contact with solvent 2. The solvent is allowed to rise 0·50 m. The appearance of the chromatogram is then



B-43 The R_f value for spot O using solvent 2 is approximately

76

A

A 0·82. **B** 0·58. **C** 0·41. **D** 0·29.

B-44 The substance in spot P is

20

B

A proline only.

B β-phenylamine only.

C threonine only.

D proline and/or β-phenylamine.

B-45 If a mistake had been made and solvent 1 was used instead of solvent 2 in the second stage, the chromatogram would be similar to

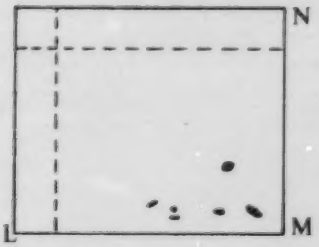
73

D

A Chromatogram 1 above.

B

C



D

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B-46
70
B

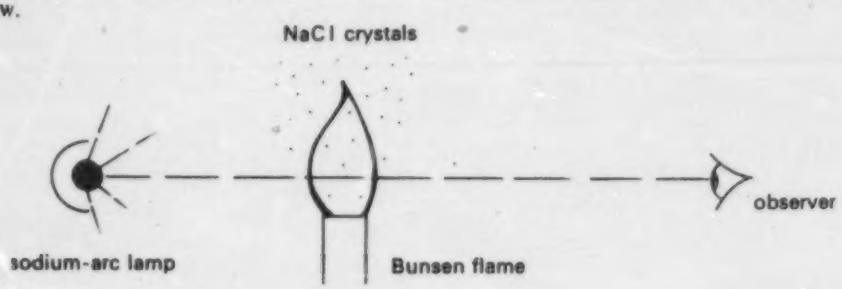
Flame tests may be used to determine if sodium is likely to be present in a chemical.

This procedure is an example of

A quantitative analysis.
B qualitative analysis.
C gravimetric analysis.
D atomic absorption spectroscopy.

B-47
30
A

A Bunsen flame is placed in front of the yellow beam of light from a sodium-arc lamp, as shown in the diagram below.



If a small quantity of sodium chloride crystals were sprinkled into the flame, the light passing through the flame would appear

A less intense, as sodium ions in the flame would absorb light.
B unchanged, as light would be absorbed and emitted in equal amounts.
C more intense, as light would be emitted from excited sodium ions in the flame.
D more intense, as light would be emitted from both the excited sodium and chloride ions in the flame.

B-48
54
B

A major advantage of atomic absorption spectroscopy as compared with flame tests in analysing chemical samples is that

A the samples do not have to be heated as strongly.
B it is possible to identify the presence of more than one element in a sample.
C it is specific for metals in Group I and II of the periodic table.
D the samples are not destroyed during the analysis.

B-49
64
A

In order to obtain the absorption spectrum of a material in solution a 'blank' is used. The blank contains pure solvent and is mainly used in order to

A allow for absorption by the solvent.
B provide an alternative pathway for the light.
C prevent absorption by molecules in air.
D prevent excitation of solvent molecules.

B-50
55
D

Many solutions employed in the laboratory are coloured. Which of the following statements concerning the absorption of light by solutions is **incorrect**?

A The amount of light absorbed by a solution depends on the concentration.
B The absorption of light by a solution may be used to determine the substances present.
C Red solutions absorb light in the green and blue regions of the spectrum.
D Each species in a solution absorbs light of a single wavelength.

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UNIT C

Preparative chemistry

C-1 51 **B**

The Cu^{2+} ions in a solution of copper(II) sulfate are

A involved in ion-dipole bonding to the hydrogen atoms of water molecules.
B electrostatically attracted to the oxygen atoms of water molecules.
C attracted to nearby water molecules by dispersion forces only.
D bonded to negatively charged sulfate groups.

C-2 71 **A**

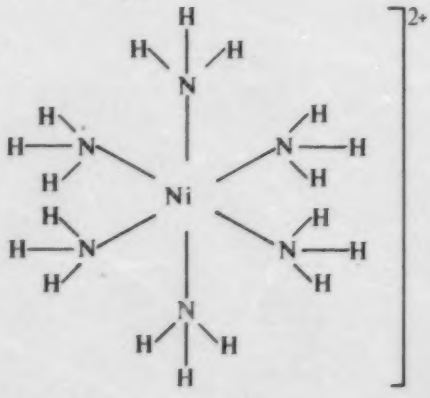
Which one of the following kinds of bonds exists between the copper and nitrogen atoms in the $Cu(NH_3)_4^{2+}$ complex?

A ion-dipole
B ionic
C covalent
D hydrogen

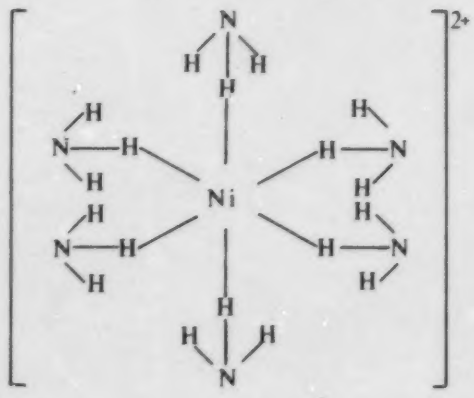
C-3 78 **D**

Which of the following best represents the structural formula of the complex $Ni(NH_3)_6^{2+}$?

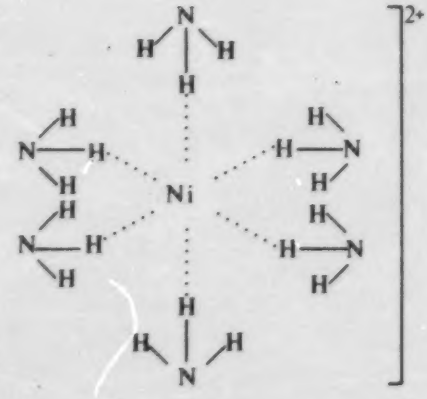
A



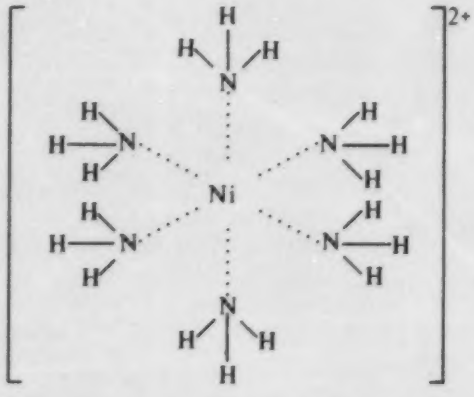
C



B



D



C-4 75 **A**

A ligand is best described as a

A molecule or ion which bonds to a central ion.
B complex ion containing neutral molecules surrounding a central ion.
C species containing ions surrounding an oppositely charged central ion.
D complex ion containing molecules attached to a cation at more than one point.

C-5 63 **C**

The ligand in $Fe(NO_3)_3.6H_2O$ is the species

A Fe^{3+}. **B** NO_3^-. **C** H_2O. **D** $Fe(NO_3)_3$.

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C-6 20 C

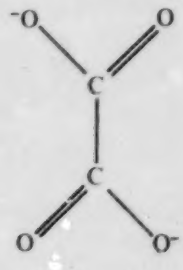
Which of the following species is **least** likely to act as a ligand?

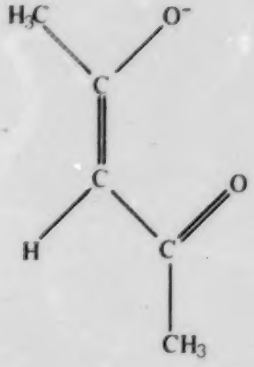
A PH_3
B CN^-
C NH_4^+
D $NH_2CH_2CH_2NH_2$

C-7 42 D

Which of the following species could **not** act as a chelating ligand?

A $NH_2CH_2CH_2NH_2$

B 

C 

D $CH_3CH_2CH_2CH_2S^-$

C-8 52 D

Which of the following complexes contains the Ni^{2+} ion?

A $Ni(CN)_4^{4-}$
B $Ni(NH_3)_2Br_3$
C $Ni(NH_2CH_2CH_2NH_2)_2Cl_2^{2+}$
D $Ni(NH_3)_2Cl_2$

C-9 62 E

Which of the following is the most likely formula for an iron(III) complex with the oxalate anion ($^-OOCCOO^-$)?

A $Fe(Ox)_3$
B $Fe(Ox)^{3+}$
C $Fe(Ox)_3^{3+}$
D $Fe(Ox)_2^{3+}$
E $Fe(Ox)_3^{3-}$

C-10 79 D

The acetylacetonate anion ($acac^-$) forms a non-polar complex with Ni^{2+} ions. The most likely empirical formula for this complex is

A $Ni(acac)_6^{4-}$.
B $Ni(acac)_3$.
C $Ni(acac)_3^{2-}$.
D $Ni(acac)_2$.

C-11 37 B

A sample of hydrated copper(II) sulfate, $CuSO_4.5H_2O$, is used to prepare tetrammine copper(II) sulfate, $Cu(NH_3)_4SO_4.H_2O$. The percentage of sulfur by mass in the final product, compared with that of the hydrated copper(II) sulfate, is (given A_r: Cu = 63·5, S = 32, O = 16, N = 14, H = 1)

A the same.
B larger.
C smaller.
D dependent upon the initial mass of reactant.

C-12 64 B

Tetrammine copper(II) sulfate may be prepared by the reaction

$$CuSO_4(aq) + 4NH_3(aq) \rightarrow Cu(NH_3)_4SO_4(aq).$$

In a particular experiment, 3·80 g of anhydrous copper(II) sulfate (M_r = 159·5) was treated with excess NH_3 solution. Ethanol was added to the mixture and 2·32 g of solid $Cu(NH_3)_4SO_4.H_2O$ (M_r = 245·5) was obtained. The percentage yield would be

A $\frac{2{\cdot}32 \times 100}{3{\cdot}80}$ %.
B $\frac{2{\cdot}32 \times 159{\cdot}5 \times 100}{245{\cdot}5 \times 3{\cdot}80}$ %.
C $\frac{3{\cdot}80 \times 100}{2{\cdot}32}$ %.
D $\frac{3{\cdot}80 \times 245{\cdot}5 \times 100}{159{\cdot}5 \times 2{\cdot}32}$ %.

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C-13
64
A

Consider the following reactions:

$Ag^+ + 2Cl^- \rightleftharpoons AgCl_2^-$	$K_{s1} = 1{\cdot}1 \times 10^5$
$Ag^+ + 2CN^- \rightleftharpoons Ag(CN)_2^-$	$K_{s1} = 1{\cdot}0 \times 10^{21}$
$Ag^+ + 2S_2O_3^{2-} \rightleftharpoons Ag(S_2O_3)_2^{3-}$	$K_{s1} = 1{\cdot}0 \times 10^{13}$
$Ag^+ + 2NH_3 \rightleftharpoons Ag(NH_3)_2^+$	$K_{s1} = 1{\cdot}6 \times 10^7$

Which of the following statements is correct?

A $Ag(S_2O_3)_2^{3-}$ would be the predominant complex in a solution formed by mixing 2 mole of $S_2O_3^{2-}(aq)$ with 1 mole of $Ag(NH_3)_2^+(aq)$.

B $AgCl_2^-$ would be the predominant complex in a solution formed by mixing 2 mole of $Cl^-(aq)$ with 1 mole of $Ag(S_2O_3)_2^{3-}(aq)$.

C $Ag(NH_3)_2^+$ would be the predominant complex in a solution formed by mixing 2 mole of $NH_3(aq)$ with 1 mole of $Ag(CN)_2^-(aq)$.

D $AgCl_2^-$ would be the predominant complex in a solution formed by mixing 2 mole of $CN^-(aq)$ with 1 mole of $AgCl_2^-(aq)$.

C-14
48
A

The compound $Cr(NH_3)_6SO_4$ is likely to be most soluble in

A water.
B ethanol.
C carbon tetrachloride.
D benzene.

C-15
41
D

Crystals of $Ni(NH_3)_6SO_4$ would be likely to dissolve in

A ethanol and be precipitated by the addition of water.
B water and be precipitated by the addition of benzene.
C chloroform and be precipitated by the addition of water.
D water and be precipitated by the addition of ethanol.

C-16
67
A

Which of the following compounds is likely to be **least** soluble in water?

A $Cu(acac)_2$
B $Cu(en)_2SO_4$
C $Cu(NH_3)_4SO_4.H_2O$
D $(NH_4)_2CuCl_4$

C-17
78
C

Which of the statements below best describes a functional group?

A It is the non-polar section in an organic molecule.
B It is a highly reactive group of elements with similar outer shell electron configurations.
C It is an atom or a group of atoms which determines the chemical properties of a compound.
D It is the part of a chelate ligand attracted to the central ion.

C-18
55
C

Which one of the following molecules is non-polar?

A CH_3Br
B NH_3
C CCl_4
D CH_3CH_2OH

C-19
67
A,C

Which **one or more** of the following solvents is(are) non-polar?

A benzene (C_6H_6)
B ethanol (CH_3CH_2OH)
C n-hexane (C_6H_{14})
D water (H_2O)

C-20
32
A

A polar substance is dissolved in water. Which of the following solvents is most likely to precipitate the substance if it is added to the solution?

A methanol
B carbon tetrachloride
C benzene
D paraffin oil

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C-21
78
D

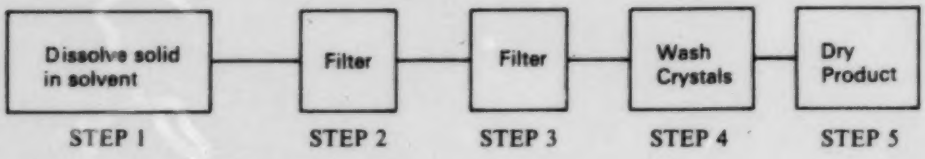
Paraffin wax is a mixture of high-molecular-mass alkanes which is often used as a waterproofing agent because of its water repellent properties and its insolubility in water. It is applied to fabrics dissolved in the solvent 'Shellite'.

From this information, it is reasonable to infer that 'Shellite'

A is soluble in water.
B has a higher relative molecular mass than water.
C is more volatile than water.
D is a non-polar solvent.

The next four questions refer to the following information.

The steps in a typical recrystallization process can be summarized as follows:



C-22
80
B

In Step 1, the solid is dissolved in a

A minimum volume of solvent at room temperature.
B minimum volume of solvent at the solvent's boiling temperature.
C large volume of solvent at room temperature.
D large volume of solvent at the solvent's boiling temperature.

C-23
71
D

In Step 2, the solution is filtered at

A room temperature to remove insoluble impurities.
B elevated temperatures to collect crystals of product.
C room temperature to collect crystals of product.
D elevated temperatures to remove insoluble impurities.

C-24
83
C

In Step 3, the solution is filtered at

A room temperature to remove insoluble impurities.
B elevated temperatures to collect crystals of product.
C room temperature to collect crystals of product.
D elevated temperatures to remove insoluble impurities.

C-25
68
B

In Step 4, the crystals are **usually** washed with

A the filtrate from Step 3.
B pure solvent.
C a non-polar solvent.
D a polar solvent.

C-26
87
B

In the recrystallization process, the solute must be

A appreciably more soluble in the cold solvent than in the hot.
B appreciably more soluble in the hot solvent than in the cold.
C very soluble in both hot and cold solvent.
D insoluble in both hot and cold solvent.

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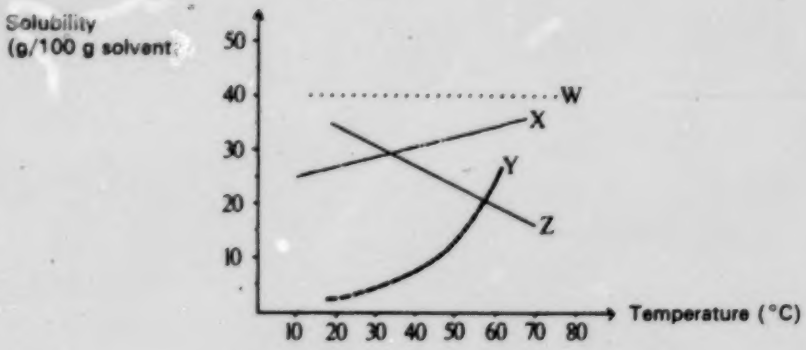
C-27
87
C

The graph below shows the variation in the solubility of a compound in solvents W, X, Y and Z with temperature.



The best solvent to use in a recrystallization of the compound would be

A W. B X. C Y. D Z.

C-28
70
C

A chemist intends to purify a substance by recrystallization.

The substance has the following solubilities (in g dm^{-3}).

	Solubility at 25 °C	Solubility at boiling temperature of solvent
water	0·6	0·9
methanol	4·8	9·1
toluene	1·2	18·0
chloroform	30·0	50·0

The best solvent to use for recrystallization is

A water.
B methanol.
C toluene.
D chloroform.

C-29
37
C

A chemist wishes to choose a solvent for a recrystallization of an impure substance. Which of the following characteristics of the solvent would be the **least** desirable?

A The solubility of the desired product in the solvent increases rapidly with temperature.
B The impurities in the substance are very soluble in the solvent at high and low temperatures.
C The desired product is very soluble in the solvent at room temperature.
D The desired product is less soluble in the solvent than any impurities present.
E The desired product is more soluble in the solvent than any impurities present.

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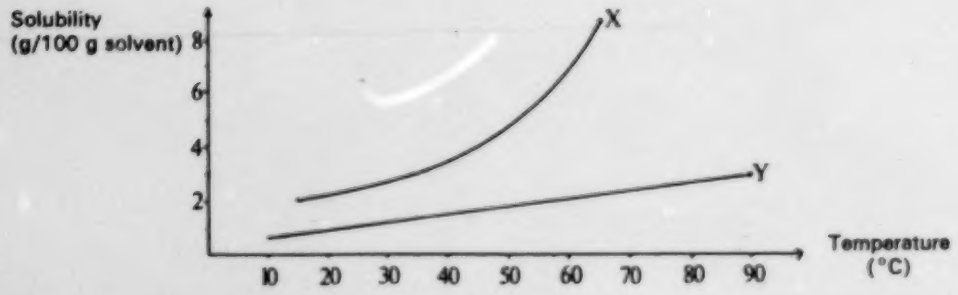
The next two questions refer to the following information

The solubility curves for a substance in solvents X and Y are shown below. Solvent X boils at 70 °C and solvent Y boils at 90 °C.



C-30
79
E

The substance would be best recrystallized using solvent

A Y, because it dissolves less substance at all temperatures.

B Y, because its boiling temperature is higher.

C X, because its solubility curve is non-linear.

D X, because its boiling temperature is lower.

E X, because the solubility decreases rapidly with decreasing temperature.

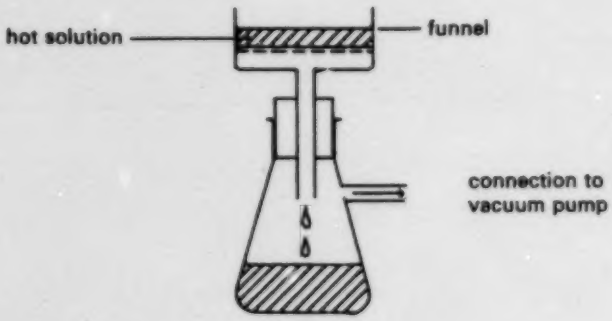
C-31
30
A

A student elects to use solvent Y for a recrystallization. If 200 g of boiling solvent were required to completely dissolve the substance, what is the maximum mass of pure substance the student could obtain when the solution is cooled to 20 °C?

A 4 g **B** 3 g **C** 2 g **D** 1 g

C-32
68
D

The hot solution prepared during a recrystallization is often filtered by vacuum filtration, using the apparatus shown below.



This filtration method is mainly used because

A the hot solvent evaporates more easily from the solute under reduced pressure.

B the solvent cools more rapidly under reduced pressure.

C oxygen is prevented from reacting with the hot solute.

D the solute is less likely to crystallize in the funnel.

C-33
84
C

Which of the following is **not** a criterion for choosing a solvent for recrystallization?

A The solute should be relatively insoluble in the solvent at room temperature.

B The solvent should have a boiling temperature between 40 °C and 120 °C.

C The solute should be more soluble in the cold solvent than in the hot.

D The solvent and solute should be chemically compatible.

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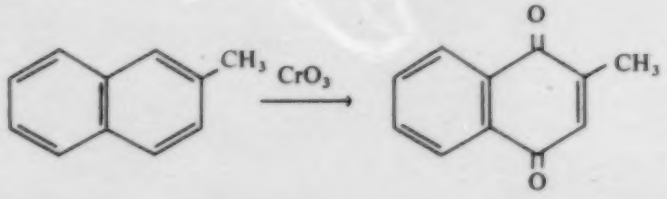
C-34
91
B

A catalyst is a substance which, when present during a chemical reaction, changes the

A amount of products obtained at equilibrium.
B rate of attaining equilibrium.
C concentration of the products at equilibrium.
D equilibrium constant at a given temperature.

C-35
49
C

Menadione, a chemical which aids blood clotting, can be prepared by the oxidation of 2-methylnaphthalene using chromium trioxide. The reaction is exothermic and acetic acid is often used as a catalyst.



2-methylnaphthalene menadione

In a particular synthesis, 1·4 g (0·01 mol) of 2-methylnaphthalene yielded 0·17 g (0·001 mol) of menadione. If the reaction was rapid, which of the following could explain the poor yield?

A use of excess chromium trioxide
B use of a catalyst other than acetic acid
C heating the reaction mixture
D precipitation of menadione as it forms

C-36
49
B

Naphthalene reacts rapidly with concentrated sulfuric acid at 160 °C to form β-naphthalenesulfonic acid, according to the equation

$$C_{10}H_8 + H_2SO_4 \rightarrow C_{10}H_7SO_3H + H_2O$$

It is desired to convert 0·1 mol of naphthalene as completely as possible into β-naphthalenesulfonic acid at 160 °C.

Which one of the following is most likely to achieve this result?

A react the naphthalene with 0·1 mol of concentrated sulfuric acid
B react the naphthalene with 2·0 mol of concentrated sulfuric acid
C react the naphthalene with 0·05 mol of concentrated sulfuric acid
D react the naphthalene with 0·1 mol of concentrated sulfuric acid in the presence of a catalyst

C-37
61
B

A synthetic pineapple essence, ethyl butanoate, is manufactured from butanoic acid and ethanol.

$$C_3H_7COOH(l) + C_2H_5OH(l) \rightleftharpoons C_3H_7COOC_2H_5(l) + H_2O(l)$$

If a mixture of butanoic acid, ethanol, ethyl butanoate and water were at equilibrium at 50 °C, adding a catalyst to the system would increase the

A value of K for the reaction at 50 °C.
B rate of the reverse reaction.
C concentration of ethyl butanoate.
D rate of the forward reaction to a greater extent than the reverse reaction.

C-38
75
D

Increasing the temperature at which reactions are performed

A increases the value of K of all reactions.
B decreases the value of K of all reactions.
C has no effect on the value of K of all reactions.
D increases the rate of most reactions.

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C-39
78
B

A chemical reaction produces m_1 gram of product. If m_2 gram were the theoretical mass of product which could be formed if the reaction proceeded to completion, the percentage yield of the reaction would be

A $\frac{m_2 - m_1}{m_2} \times 100\%$

B $\frac{m_1}{m_2} \times 100\%$

C $\frac{m_2}{m_1} \times 100\%$

D $\frac{m_2}{m_2 - m_1} \times 100\%$

C-40
43
D

Urea is manufactured industrially by the endothermic decomposition of ammonium carbamate.

$$NH_4CO_2NH_2 \rightleftharpoons NH_2CONH_2 + H_2O$$

In a particular synthesis of urea the yield was less than 100%.

Which of the following could be an explanation for the low yield?

A Urea and water were not produced in equimolar amounts.

B The equilibrium constant for the reaction is very large.

C Equilibrium is achieved at a high temperature.

D The rate of the reaction was low.

C-41
65
D

1·00 g of acetic acid (M_r = 60·1) was synthesized from 1·00 g of ethanol (M_r = 46·1). The percentage yield was

A 100%

B $\frac{14{\cdot}0 \times 100}{46{\cdot}1}$ %

C $\frac{14{\cdot}0 \times 100}{60{\cdot}1}$ %

D $\frac{46{\cdot}1 \times 100}{60{\cdot}1}$ %

E $\frac{60{\cdot}1 \times 100}{46{\cdot}1}$ %

C-42
71
C

Compared with a pure substance, an impure sample of the substance melts

A at a higher temperature and over a wider temperature range.

B at a higher temperature and over a narrower temperature range.

C at a lower temperature and over a wider temperature range.

D at a lower temperature and over a narrower temperature range.

C-43
34
A

A sample of acetanilide contains a 5% benzanilide impurity. If the melting temperatures of the pure acetanilide were 114 °C and pure benzanilide were 163 °C, the melting temperature of the sample would be most likely to be

A less than 114 °C, over a temperature range of greater than 2°.

B greater than 114 °C, over a temperature range of greater than 2°.

C less than 114 °C, over a temperature range of less than 2°.

D greater than 114 °C, over a temperature range of less than 2°.

C-44
79
A

Which of the following procedures should **not** be followed during an accurate determination of melting temperature using a paraffin oil bath?

A The sample is packed loosely in a capillary tube.

B The oil is heated gently using a Bunsen burner.

C The sample is placed directly beside the bulb of a thermometer.

D The oil is stirred regularly using a metal ring.

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C-45
44
A

Maleic acid melts at 139 °C and malonic acid melts at 136 °C. A small amount of a substance, which is known to be either maleic acid or malonic acid, is mixed with a sample of malonic acid.

As the melting temperature of this mixture is increased, it would start to melt

A below 136 °C if the substance is maleic acid.

B between 136 °C and 139 °C if the substance is maleic acid.

C at 136 °C if the substance is maleic acid.

D at 139 °C if the substance is malonic acid.

C-46
21
C

A chemist attempted to prepare four samples of urea using different synthetic methods. Three of the samples he prepared were mainly composed of urea, but the other sample he prepared was a different compound. The melting temperatures of the four samples (W, X, Y and Z) are given in the table below.

	W	X	Y	Z
melting range (°C)	127–131	131–133	126–127	124–130

Which of the samples is probably **not** urea?

A W **B** X **C** Y **D** Z

C-47
70
A,C

A student is provided with four samples of chemicals labelled W, X, Y and Z. Each sample has a sharp melting temperature of 44 °C. The student finds that a mixture of X and Y melts between 35 °C and 40 °C, as does a mixture of Y and Z. However, a mixture of W, X and Z melts at 44 °C.

Which **one or more** of the samples X, Y, Z could be the same chemical as W?

A X **B** Y **C** Z

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UNIT D

Surface chemistry

Unit D

D-1 93 **A**

Which of the following is **not** an example of a simple interface?

A gas–gas
B gas–liquid
C solid–solid
D liquid–liquid

D-2 86 **C**

Which of the following processes or phenomena is **not** associated with a liquid–gas interface?

A foams
B froths
C emulsions
D distillation

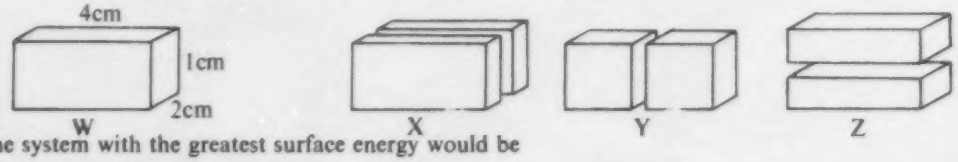
D-3 79 **D**

When a glass bottle is broken

A the total surface energy remains constant.
B the total surface area remains constant.
C the surface tension is decreased.
D energy is stored in the surface of the broken pieces.

D-4 46 **D**

A block of wood, W, can be cut in half in three different ways as shown by X, Y and Z.



The system with the greatest surface energy would be

A W. **B** X. **C** Y. **D** Z.

D-5 31 **B**

A cube of iron is equally divided into eight smaller cubes. The fraction

$$\frac{\text{total surface energy of the original cube}}{\text{total surface energy of the eight cubes}}$$

will be approximately

A 1. **B** $\frac{1}{2}$. **C** $\frac{1}{4}$. **D** $\frac{1}{8}$. **E** $\frac{1}{64}$.

D-6 59 **D**

A material has a surface energy of $0{\cdot}10\ \text{J m}^{-2}$. The total surface energy of a block of the material $4{\cdot}0$ m long, $3{\cdot}0$ m wide and $2{\cdot}0$ m deep is

A $0{\cdot}10\ \text{J m}^{-2}$.
B $1{\cdot}40\ \text{J m}^{-2}$.
C $2{\cdot}40\ \text{J m}^{-2}$.
D $5{\cdot}20\ \text{J m}^{-2}$.

D-7 47 **A**

The surface tension of a liquid is the

A force acting per unit length of surface.
B force acting per unit area of surface.
C energy acting per unit length of surface.
D pressure acting per unit area of surface.

D-8 73 **A**

A fine needle can float on clean water because the

A water–air surface tension overcomes the needle's weight.
B metal–air surface tension is greater than the weight of the water displaced.
C water–air surface tension is equal to the water–metal surface tension.
D water–metal surface tension is greater than the needle's weight.

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D-9 72 **A**

Surface tension has the units

A $N\,m^{-1}$. **B** $J\,m$. **C** $N\,m^{-2}$. **D** $J\,m^{-1}$.

D-10 85 **D**

The unit $N\,m^{-1}$ which is used for surface tension is dimensionally equivalent to

A J. **B** $J\,m$. **C** $J\,m^{-1}$. **D** $J\,m^{-2}$.

D-11 53 **A**

The surface tension of a liquid can be measured by the dipping plate method. This method is an example of a

A static technique.
B capillary technique.
C dynamic technique.
D dropping technique.

D-12 77 **D**

Which of the following measurements is **not** required in the determination of surface tension by the dipping plate method?

A the mass required to balance the plate
B the perimeter of the plate's base
C the acceleration due to gravity
D the solid–vapour surface tension

The next three items refer to the following information:

The surface tension of a liquid can be measured by the drop weight method. This method is based upon the way surface tension opposes the gravitational force on a hanging drop.

D-13 91 **C**

The formula used to determine surface tension by the drop weight method is

A $\gamma = \dfrac{mgz}{2(l+a)}$.
B $\gamma_{SL} = \gamma_{SG} + \gamma_{LG}\cos\theta$.
C $\gamma = \dfrac{mg}{2\pi Rf}$.
D $\gamma = \dfrac{h\Delta\rho gr}{2\cos\theta}$.

D-14 81 **A**

If the drops of water ($\gamma = 72\ mN\,m^{-1}$) falling from a particular capillary tube have mass 0·060 g, the mass of drops of acetone ($\gamma = 24\ mN\,m^{-1}$) which would fall from the capillary tube is

A 0·020 g. **B** 0·060 g. **C** 0·120 g. **D** 0·180 g.

D-15 37 **B**

The surface tension of drops of a liquid falling from a 4 mm capillary tube, compared to that of drops of the same liquid falling from a 2 mm capillary tube, is

A half as large.
B unchanged.
C twice as large.
D four times as large.

D-16 76 **C**

The term **adsorption** is used in the study of surface chemistry to refer to the

A dissolution of hydrophobic liquids in surfactants.
B wetting of a solid by a surface active agent.
C process of concentration of molecules at interfaces.
D rise or fall of liquids in capillary tubes.

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D-17 64 B

A hydrophobic substance is a substance which is

A 'water-hating' and has a high surface energy.
B 'water-hating' and has a low surface energy.
C 'water-loving' and has a high surface energy.
D 'water-loving' and has a low surface energy.

D-18 79 C

In which of the following formulae for the surfactant lauric acid has the hydrophilic part been underlined?

A $\underline{CH_3(CH_2)_{10}}COOH$
B $\underline{CH_3(CH_2)_{10}C}OOH$
C $CH_3(CH_2)_{10}\underline{COOH}$
D $CH_3\underline{(CH_2)_{10}COOH}$

D-19 83 C

Which one of the following clean substances is naturally hydrophilic?

A paraffin wax
B Teflon
C diamond
D plastic

D-20 45 A,B

Which **one or more** of the following could occur after repeated handling of a clean glass plate?

A The total surface energy of the glass decreases.
B The glass surface becomes hydrophobic.
C Water spreads more evenly on the glass surface.
D The contact angle (measured through air) of water drops placed on the glass surface increases.

D-21 47 A

If a liquid completely wets a solid, the contact angle measured through the liquid is

A 0°. B 45°. C 90°. D 180°.

D-22 46 C

Glasses are often rinsed in water after they have been washed.
If droplets of water adhere to the glass surface, a glass is

A clean because water wets clean glass.
B clean because water does not wet clean glass.
C not clean because water wets clean glass.
D not clean because water does not wet clean glass.

D-23 42 D

Mercury spilled on a glass surface rapidly forms into drops. As the mercury 'balls up' into a drop the

A surface tension of glass against air is increasing.
B surface tension of mercury against air is decreasing.
C total surface energy of the glass against mercury is increasing.
D total surface energy of the mercury against air is decreasing.

D-24 67 C

Ethanol acts as a surfactant in water. The proportion of ethanol in an alcoholic drink can be estimated from the contact angle of a drop of the drink (measured through the air) on your hand. As the proportion of alcohol in a drop increases, the surface tension

A increases and the contact angle increases.
B increases and the contact angle decreases.
C decreases and the contact angle increases.
D decreases and the contact angle decreases.

D-25 35 B

Water shows a concave meniscus in a clean platinum tube, whereas water has a convex meniscus in a Teflon tube.
The surface energies of platinum, water and Teflon increase in the order

A platinum, water, Teflon.
B Teflon, water, platinum.
C water, platinum, Teflon.
D Teflon, platinum, water.

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D-26
46
B

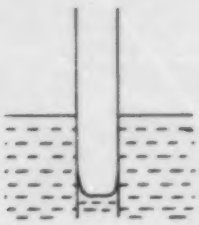
Benzene has a concave meniscus in a clean glass tube, whereas mercury has a convex meniscus. Which of the following statements is true?

A Benzene has a larger surface tension than mercury and it will wet mercury.
B Benzene has a smaller surface tension than mercury and it will wet mercury.
C Benzene has a larger surface tension than mercury and it will not wet mercury.
D Benzene has a smaller surface tension than mercury and it will not wet mercury.

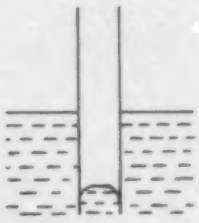
D-27
72
C

If a liquid does not wet glass, the appearance of the liquid in a glass capillary tube is best represented by

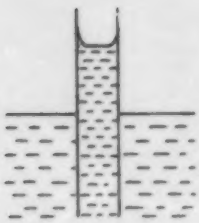
A



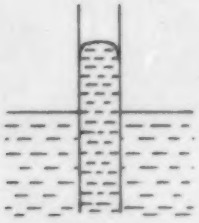
C



B



D



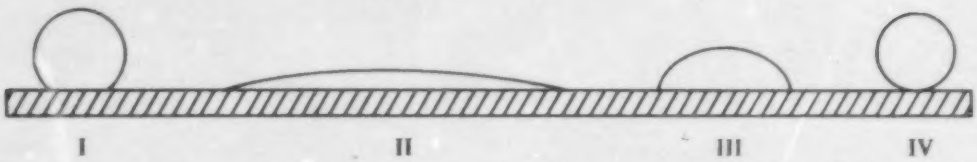
D-28
60
B

If a liquid has a concave meniscus in a capillary tube, the adhesive force between the liquid and glass would be

A greater than the surface tension of the liquid.
B greater than the cohesive force within the liquid.
C less than the cohesive force within the liquid.
D less than the surface tension of the liquid.

The next three items refer to the following information:

The following diagrams represent side on views of drops on a waxy surface.



D-29
93
B

If the drop in III is pure water, the appearance of a drop of detergent solution is best represented by

A I. **B** II. **C** III. **D** IV.

D-30
92
B

The drop with the largest contact angle measured through air is

A I. **B** II. **C** III. **D** IV.

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D-31 69 **A**

The surface tension of the drops increase in the order

A II, III, I, IV.
B II, I, III, IV.
C IV, III, I, II.
D IV, I, III, II.

D-32 84 **C**

Which of the following statements about a concentrated solution of detergent in water is correct?

A It has a higher surface energy than that of clean glass.
B There is an even distribution of detergent molecules throughout the liquid.
C It has a lower surface tension than that of water.
D It has more hydrophilic character than pure water.

D-33 85 **D**

The operation of a detergent in washing oily plates involves

A redeposition of oil drops due to repulsion between polar head groups of surfactant molecules.
B adsorption of polar head groups of surfactant molecules in oil droplets.
C froth flotation of hydrophilic oil droplets.
D conversion of a hydrophobic surface to a hydrophilic one.

D-34 69 **D**

Redeposition of oil particles when dinner plates are washed is mainly prevented by repulsion between the

A hydrophobic oil molecules and the hydrophobic plate surface.
B hydrophobic part of detergent molecules attached to the oil and the hydrophilic plate surface.
C hydrophilic part of detergent molecules attached to the oil and the hydrophilic plate surface.
D polar groups in detergent molecules attached to the oil and polar groups in detergent molecules near the plate surface.

The next two items refer to the following information:

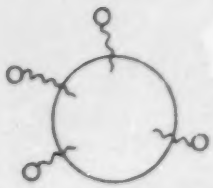
A surfactant molecule may be represented by the symbol below.

D-35 86 **B**

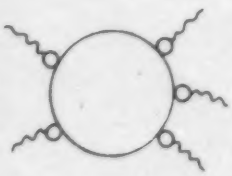
Which of the following diagrams best represents the orientation of surfactant molecules about a droplet of oil in water?

A

B



C



D

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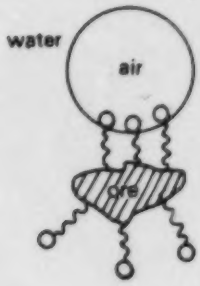
D-36 83 **D** Which of the diagrams below best represents the action of surfactant molecules during froth flotation?

A



C

B

D

D-37 74 **A** Froth flotation is used during the extraction of copper to sort the mineral from impurities. In the process of froth flotation

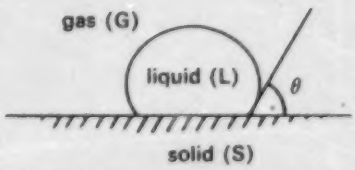
A hydrophilic mineral particles become hydrophobic by adsorption of a surfactant.
B hydrophobic mineral particles become hydrophilic in the presence of the frother.
C hydrophobic mineral particles become hydrophilic by adsorption of a surfactant.
D hydrophilic mineral particles become hydrophobic in the presence of the frother.

D-38 88 **D** In which of the following cases is a glue **least** likely to join two materials?

A The surface energies of both materials are high.
B One of the surfaces is hydrophilic.
C The glue is hydrophilic.
D The glue does not wet both materials.

The next three items refer to the following information:

A drop of water rests on a solid as shown.



D-39 56 **C** Which of the following equations is correct?

A $\gamma_{SG} = \gamma_{LG} + \gamma_{SL} \cos \theta$
B $\gamma_{SL} = \gamma_{SG} - \gamma_{LG} \cos \theta$
C $\gamma_{SG} = \gamma_{SL} - \gamma_{LG} \cos \theta$
D $\gamma_{SL} = \gamma_{LG} + \gamma_{SG} \cos \theta$

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D-40
67
A

The shape of the drop of water suggests that the solid could be clean

A Teflon.
B glass.
C aluminium.
D diamond.

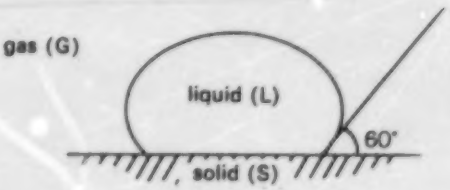
D-41
58
D

If the drop of water were replaced by a drop of detergent solution

A θ and γ_{LG} would be smaller.
B θ and γ_{LG} would be larger.
C θ would be smaller and γ_{LG} would be larger.
D θ would be larger and γ_{LG} would be smaller.

D-42
66
C

The diagram below represents a drop of liquid on a surface.

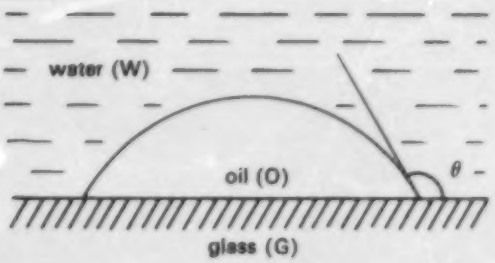


If the surface tension γ_{LG} were 40 mN m^{-1} and the surface tension γ_{SG} were 100 mN m^{-1}, the surface tension γ_{SL} would be

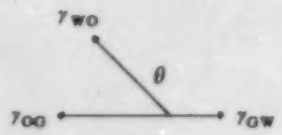
A 60 mN m^{-1}.
B 80 mN m^{-1}.
C 120 mN m^{-1}.
D 140 mN m^{-1}.

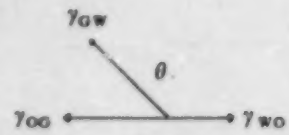
D-43
70
A

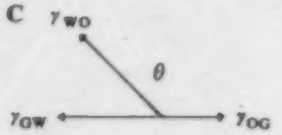
A drop of oil rests on the bottom of a beaker of water.

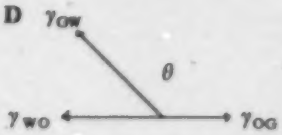


Which of the following diagrams best represents the forces acting at a point where oil, glass and water are in contact?

A


B


C


D


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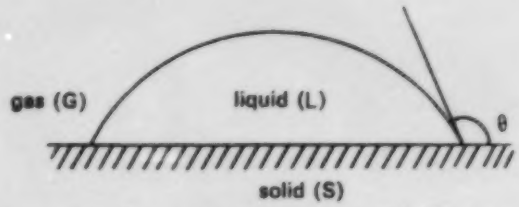
D-44
82
B

A drop of liquid rests on a surface as shown.



If the surface tensions γ_{SG}, γ_{SL} and γ_{LG} were 100, 60 and 50 mN m^{-1} respectively, then the value of cos θ would be

A $-\frac{1}{10}$. B $-\frac{4}{5}$. C $-\frac{5}{6}$. D $-\frac{16}{5}$.

D-45
87
A

An emulsion consists of

A small drops of one liquid dispersed in another liquid.
B particles of liquid dispersed in a gaseous medium.
C small particles of a solid dispersed in a liquid.
D small drops of a liquid dispersed in a solid.

D-46
86
D

Which of the following substances is **not** an emulsion?

A homogenised milk
B mayonnaise
C cosmetic cold cream
D dilute soap solution

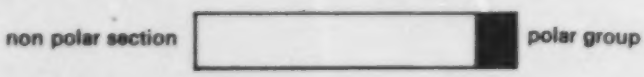
D-47
17
C

Many substances will form either a temporary or a stable emulsion when shaken with water. Which of the following liquids is **least** likely to do this?

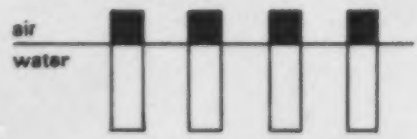
A n-octyl alcohol ($CH_3(CH_2)_7OH$)
B n-decane ($C_{10}H_{22}$)
C ethanol (C_2H_5OH)
D benzene (C_6H_6)

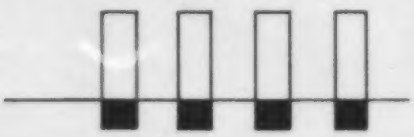
D-48
90
C

Large molecules like cholesterol may be represented by the following symbol.

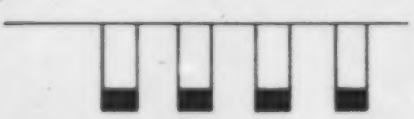


Which of the diagrams below best represents the way these molecules would arrange themselves at the surface of water?

A


C


B

D


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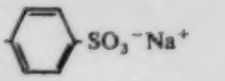
D-49
44
A

Which of the following compounds is most likely to form a monolayer when added to water?

A $CH_3(CH_2)_{15}OH$

B 

C $CH_3(CH_2)_3COO^-Na^+$

D CH_3COOH

D-50
78
B

A monolayer of hexadecanol is sometimes placed on the surface of a dam in order to reduce the rate of evaporation. Evaporation is reduced because the

A surface tension of the water in the dam is increased.

B water molecules must pass through small spaces between the hexadecanol molecules in order to escape.

C polar end of the monolayer forms hydrogen bonds with neighbouring water molecules.

D monolayer reflects heat more efficiently than a water-air interface.

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UNIT E

Carbon and silicon giant molecules

Unit E

E-1 82 **A**

Which one of the substances below is a copolymer?

A nylon
B poly(styrene)
C natural rubber
D Teflon

E-2 62 **C**

A linear polymer is a polymer in which

A no side branches are present.
B the chains are aligned parallel to each other.
C there is no cross linking.
D the atoms are arranged in a row.

E-3 47 **B**

A range of mineral oils consists of linear polymers with the general formula C_nH_{2n+2}. For such oils, which of the following would be expected to decrease as the value of n increases?

A boiling temperature
B ease of combustion
C relative molecular mass
D viscosity

E-4 55 **B**

Which of the following substances would **not** be likely to act as a monomer?

A $Cl_2C=CCl_2$
B $CH_3CH_2CH_2CH_2NH_2$
C $(C_2H_5)_2Si(OH)_2$
D $CH_3Si(OH)_3$

E-5 84 **B**

As the chain length of polymer molecules increases, the polymer tends to

A melt at lower temperatures.
B become more viscous.
C become less dense.
D become more soluble in non-polar solvents.

E-6 50 **B**

Which one of the following terms could **not** be used to describe the processes involved in the formation of poly(vinyl chloride) from vinyl chloride?

A polymerisation
B condensation
C saturation
D addition

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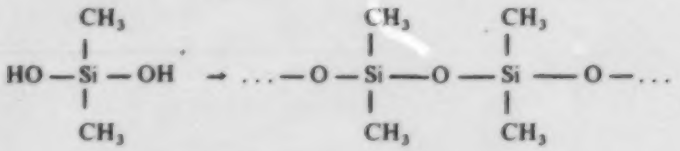
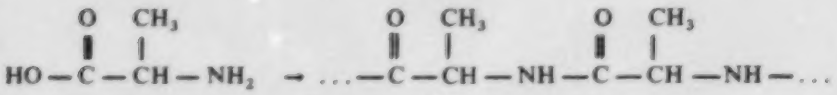
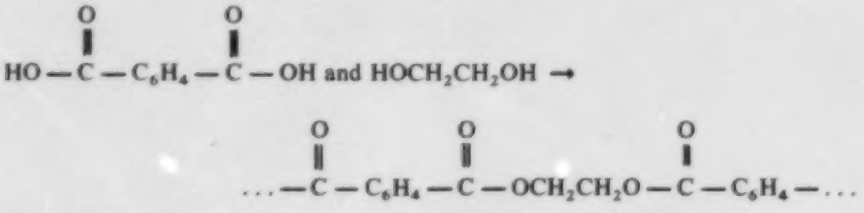
E-7
80
D

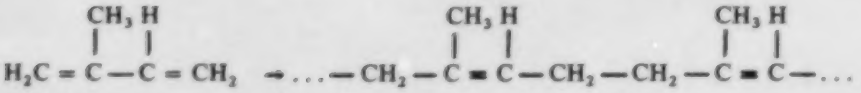
The structures of monomers and the polymers which can be made from them are shown below. Which polymer is made by addition polymerisation?

MONOMER(S) POLYMER

A 

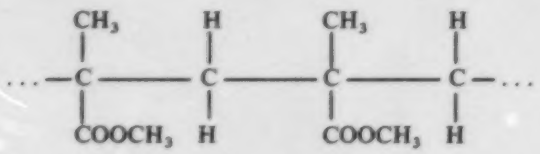
B 

C 

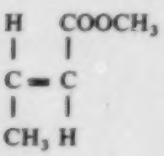
D 

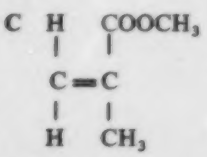
E-8
79
C

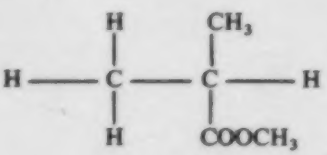
A polymer used in the manufacture of artificial eyes has the structure

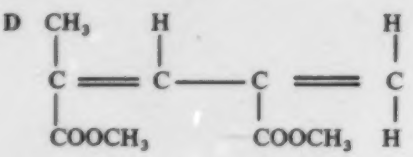


The monomer(s) for this polymer would be

A 

C 

B 

D 

E-9
49
B

Poly(ethylene) can be prepared in low density and high density forms. Low density poly(ethylene) is formed using

A high pressures and a Ziegler-Natta catalyst.
B high pressures and an organic peroxide catalyst.
C low pressures and a Ziegler-Natta catalyst.
D low pressures and an organic peroxide catalyst.

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E-10 67 **B**

The difference in strength between high and low density poly(ethylene) is most directly attributable to the

A degree of cross linking.
B degree of side branching.
C relative molecular masses.
D alignment of hydrogen atoms along the chain.

E-11 52 **C**

Poly(ethylene) can be manufactured in two distinct forms. Form I has a relative molecular mass around 200 000, whereas Form II has a relative molecular mass up to 50 000.

If Form I has a melting temperature of about 135 °C, Form II could melt at

A 170 °C and be more permeable to air.
B 170 °C and be less permeable to air.
C 105 °C and be more permeable to air.
D 105 °C and be less permeable to air.

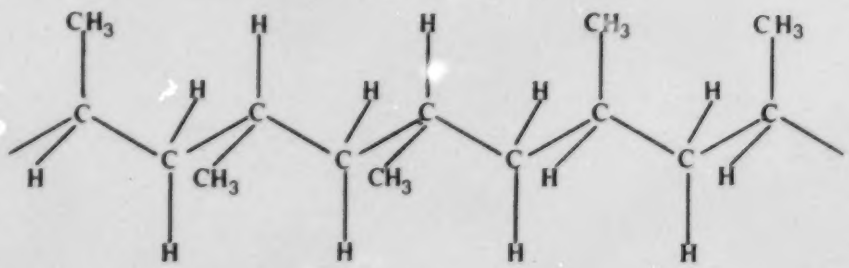
E-12 61 **D**

Harsh reaction conditions are used to prepare a soft variety of poly(ethylene).

Such conditions cause some C–H bonds to be broken and, as a result,

A cross linking of adjacent chains occurs at these points.
B a double bond forms in the polymer chain at these points.
C the polymer chain terminates at these points.
D a branch in the polymer chain occurs at these points.

The next question refers to the following structure



E-13 63 **C**

A polymer with the structure shown above is likely to be

A a copolymer.
B an isotactic polymer.
C an atactic polymer.
D a condensation polymer.

E-14 54 **B**

Propylene can polymerise in two different forms, Form I and Form II. In Form I all the side groups lie on the same side of the main chain of the polymer, whereas in Form II the side groups are randomly orientated with respect to the chain.

Which of the following statements about these polymers is correct?

A Form I has more extensive cross linking.
B Form I has stronger dispersion forces between chains.
C Form II has more extensive cross linking.
D Form II has the higher melting temperature.

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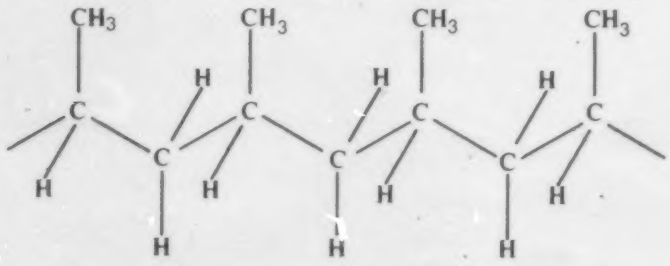
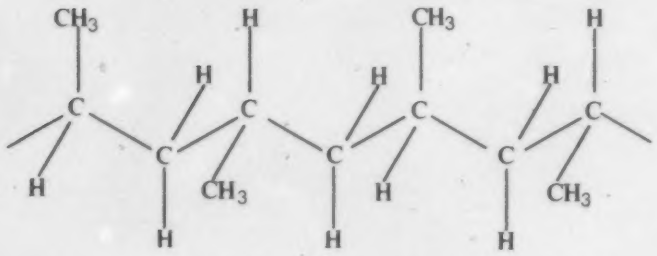
E-15 65 **A**

Which one of the following structural formulae best represents isotactic poly(propylene)?

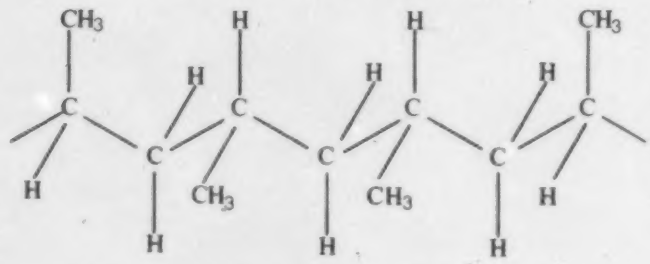
A



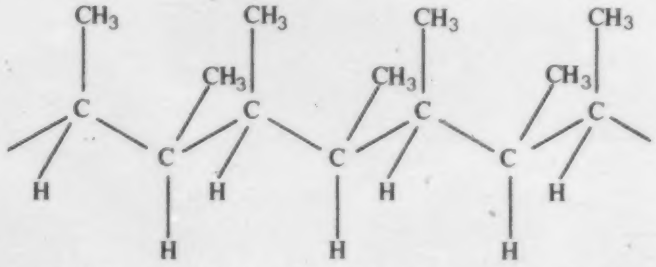
B



C



D



E-16 53 **D**

Compared with atactic poly(propylene), isotactic poly(propylene)

A has a lower melting temperature.

B is softer.

C has more side branches.

D is formed at lower pressure.

E-17 71 **A**

When a polymer is formed by condensation polymerisation

A the mass of polymer formed is less than the combined mass of the reactants.

B it must be a copolymer.

C the product must have a cross linked structure.

D the product must be isotactic.

E-18 65 **D**

Which of the following molecules is most likely to undergo extensive polymerisation with itself?

A $(CH_3)_3COH$

B $H_2N(CH_2)_6NH_2$

C $ClOC(CH_2)_4COCl$

D $H_2N(CH_2)_5COCl$

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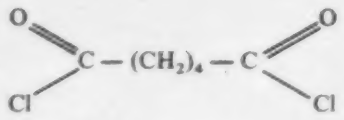
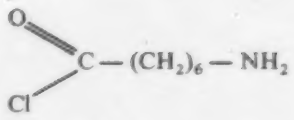
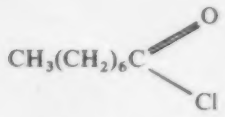
The next two items refer to the following compounds

I 

III 

II $NH_2 - (CH_2)_6 - NH_2$

IV 

E-19 39 C

Which one of these compounds (under appropriate temperature and catalytic conditions) would polymerise by itself?

A I **B** II **C** III **D** IV

E-20 64 C

Which two of these compounds could polymerise to produce nylon 6.6?

A I and IV **C** I and II
B II and III **D** I and III

E-21 73 A

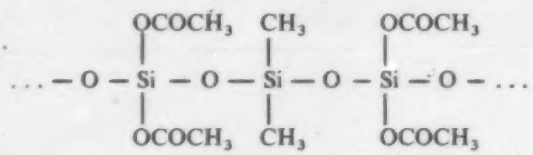
Fibres formed from isotactic poly(propylene) are not as strong as fibres formed from nylon. This is mainly a consequence of

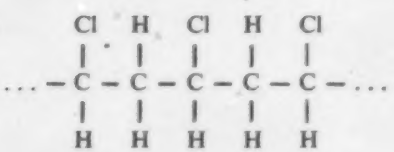
A hydrogen bonding between nylon chains.
B the random arrangement of CH_3- side chains in poly(propylene).
C extensive branching of the poly(propylene) chains.
D cross linking between nylon chains.

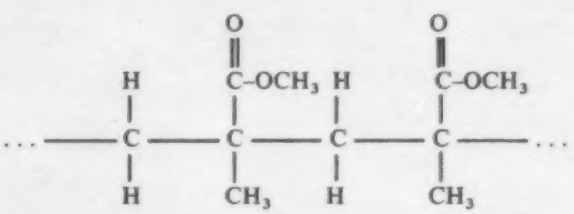
E-22 54 D

Hydrogen bonding between adjacent chains enhances the fibre strength of some polymers. The structures of four polymers are represented below.

In which case could hydrogen bonding occur between chains?

A 

B 

C 

D

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E-23 The elastic properties of nylon can be improved by mildly heating it, and gently stretching the thread at the same time.

45

B The best explanation for this is that

A the heat supplied is sufficient to overcome the weak bonding forces in the chains, thus creating smaller but more tangled fragments.

B this procedure causes greater regularity in the lining up of the long chains, and therefore more hydrogen bonding.

C the heat causes reaction between side groups on the nylon chain, increasing the extent of cross linking.

D the chains vibrate more rapidly and become tangled. The subsequent stretching tightens the tangled chains.

E-24 Some polymers are depolymerised when heated. One polymer in particular produces a monomer with the same empirical formula as the polymer.

89

A The polymer in question is likely to be

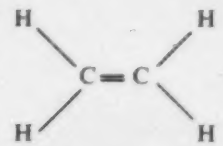
A an addition polymer.

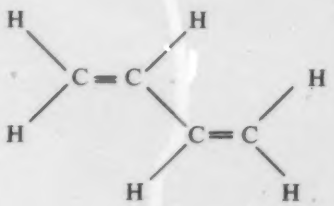
B a condensation polymer.

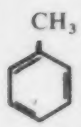
C a thermosetting polymer.

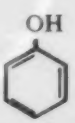
D a copolymer.

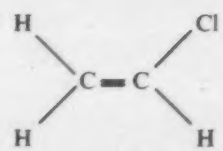
The next three items refer to the following compounds

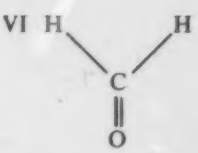
I 

IV 

II 

V 

III 

VI 

E-25 Which of the pairs of compounds below is likely to readily form a condensation polymer?

62

D

A I and IV

B I and III

C III and V

D V and VI

E-26 One of the compounds forms an addition polymer which can then be cross linked using another substance. Which one?

34

B

A III **B** IV **C** V **D** VI

E-27 Which of the pairs of compounds below is likely to form a copolymer?

41

B

A I and V

B I and III

C IV and V

D II and VI

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E-28 72 D

Addition of a catalyst to some mixtures of linear polymers can cause chemical bonds to form **between** the polymers.

The resulting compound is said to be

A atactic.
B isotactic.
C thermoplastic.
D thermosetting.

E-29 63 A

In a cross linked polymer the **major** force holding the chains together is due to

A covalent bonding.
B dispersion forces.
C hydrogen bonding.
D attraction between permanent dipoles.

E-30 93 D

Cross linked polymers and linear polymers exhibit different physical properties.

Cross linked polymers are usually relatively

A soft and melt when heated.
B soft and do not melt when heated.
C hard and melt when heated.
D hard and do not melt when heated.

E-31 89 C

Which one of the following polymers is thermosetting?

A Teflon
B nylon
C urea-formaldehyde
D poly(styrene)

E-32 66 A

Which one of the following lists contains only thermosetting polymers?

A phenol–formaldehyde; epoxyresin; silicone resin
B nylon; epoxyresin; silicone fluid
C nylon; phenol–formaldehyde; poly(propylene)
D phenol–formaldehyde; poly(propylene); silicone resin

E-33 28 A

Which of the following combinations of compounds is most likely to react to form a cross linked polymer?

A $HCHO$ and $(NH_2)_2CO$
B $H_2N(CH_2)_6NH_2$ and $ClCO(CH_2)_4COCl$
C $CH_3CH=CH_2$ and $CF_2=CF_2$
D $(CH_3)_2Si(OH)_2$ and $(CH_3)_3SiOH$

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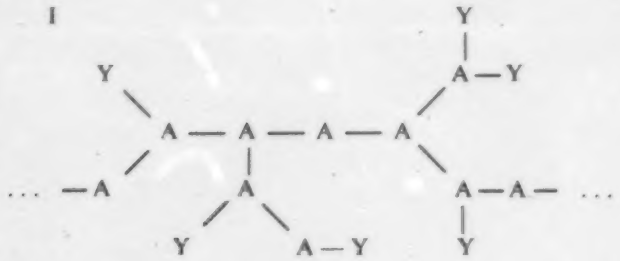
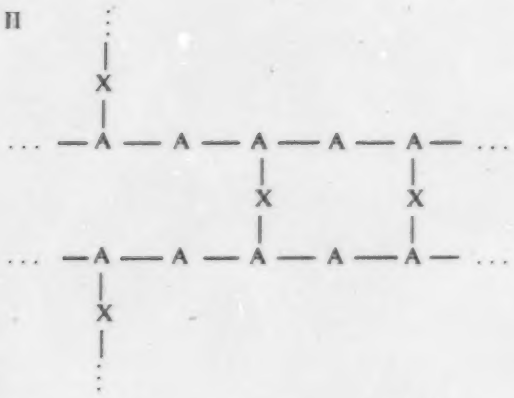
The next three questions refer to the following information

The structures of five polymers are represented by the simplified formulae below.

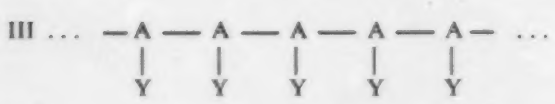
I



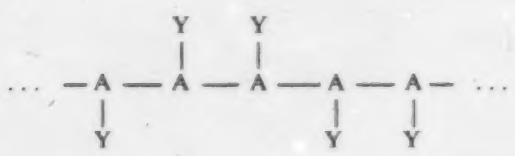
II



III



IV



A represents a hydrocarbon group (e.g. CH_2 or CH), X represents a cross linking group of atoms and Y represents an alkyl group (e.g. CH_3).

E-34 Which of these polymers could be isotactic?

61

C **A** I **B** II **C** III **D** IV

E-35 Which of these polymers is thermosetting?

68

B **A** I **B** II **C** III **D** IV

E-36 Which of these polymers would form the strongest fibres?

24

C **A** I **B** II **C** III **D** IV

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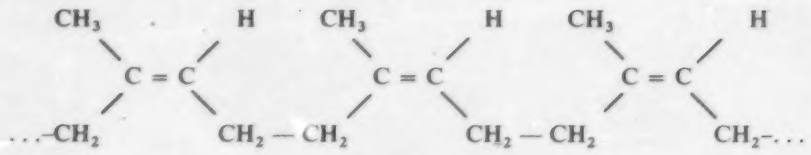
E-37 49 **A**

The structure of natural rubber is best represented by

A



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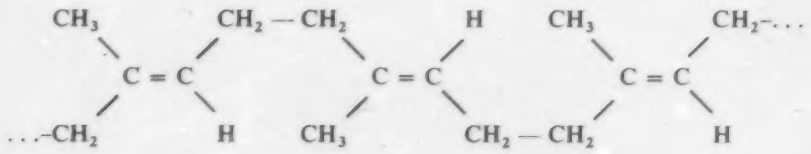

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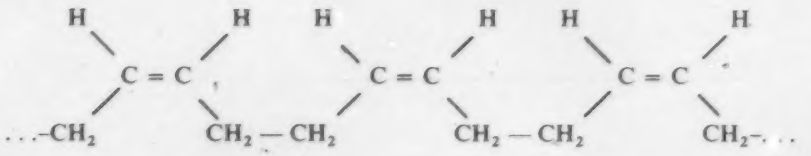

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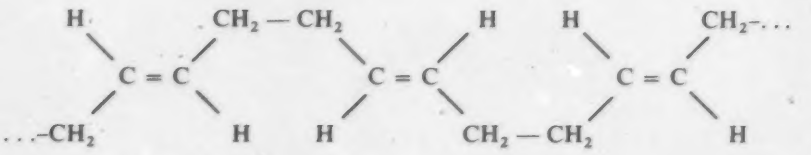

E-38 55 **A**

Natural rubber can be regarded as a polymer of isoprene molecules. It is frequently vulcanized before it is used in industry.

The formation of rubber from isoprene and the subsequent vulcanization process can be described as

A addition polymerization followed by an addition reaction.
B addition polymerization followed by a substitution reaction.
C condensation polymerization followed by an addition reaction.
D condensation polymerization followed by a substitution reaction.

E-39 77 **D**

Vulcanized rubber softens at a much higher temperature than unvulcanized rubber. This is mainly because in vulcanized rubber

A the average hydrocarbon chain length is larger.
B the chains have an isotactic configuration.
C there are stronger dispersion forces between chains.
D the chains are partially cross linked.

E-40 54 **A**

Rubber is used to make car battery cases and elastic bands. The approximate percentages of sulfur in battery cases and elastic bands are likely to be, respectively,

A 30% and 1%.
B 30% and 0%.
C 0% and 30%.
D 1% and 30%.
E 1% and 0%.

E-41 44 **C**

The major synthetic rubber used to-day is prepared from

A butadiene.
B isoprene.
C butadiene and styrene.
D isoprene and butadiene.

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E-42 60 **C**

A company producing plastic piping requires a polymer which is very rigid at normal temperatures but can be bent at high temperatures.

The most appropriate type of polymer for the company to use would be one which was

A atactic and thermoplastic.
B atactic and thermosetting.
C isotactic and thermoplastic.
D isotactic and thermosetting.

E-43 55 **C**

Which of the polymers below would be most suitable for lining the inside of cardboard milk cartons?

A urea–formaldehyde
B perspex
C low density poly(ethylene)
D epoxyresin

E-44 90 **D**

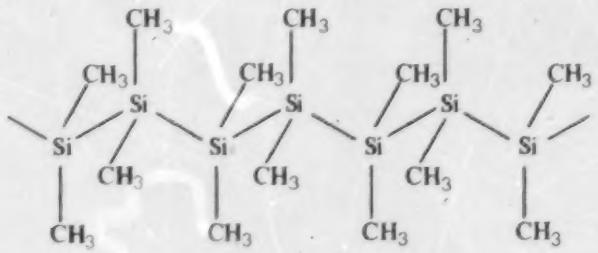
PVA glue (white glue) is used extensively to join wood surfaces.
The setting of PVA glue is a process which involves

A the formation of hydrogen bonds between chains to produce a hard thermosetting polymer.
B reaction of linear polymer chains with each other to produce an extensively cross linked polymer.
C a chemical reaction between the glue and water vapour from the atmosphere.
D the evaporation of water, leaving behind a mass of tangled linear polymers.

E-45 82 **B**

Which of the following structures could represent a part of a silicone?

A



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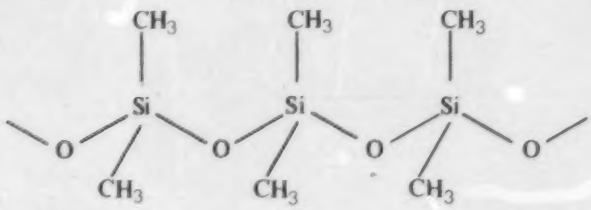

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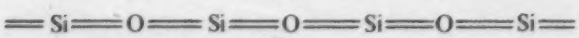

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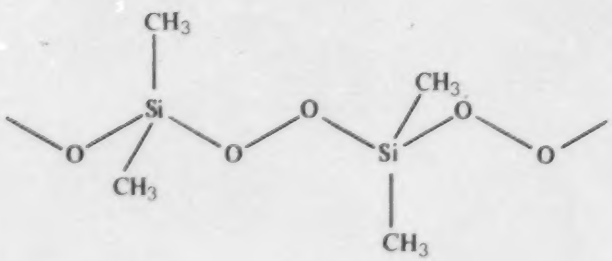

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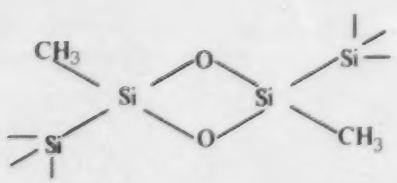

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E-46
79
C

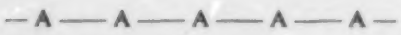
Which of the following is **not** true of silicone fluids?

A They are insoluble in water.
B They are stable at high temperatures.
C They are good electrical conductors.
D Their properties depend on the polymer chain length.

The next three questions refer to the following information

Four types of polymer can be represented by the simplified formulae below.

I



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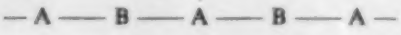
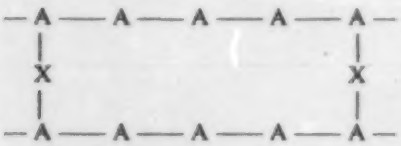


III



IV

A and B represent repeating units derived from different monomers and X represents a cross linking atom or group of atoms.

E-47
89
B

Which of these formulae could represent a copolymer?

A I B II C III D IV

E-48
17
A

Which of these formulae could represent the silicon polymer produced from the hydrolysis of $(CH_3)_2SiCl_2$?

A I B II C III D IV

E-49
80
C

Which of these formulae best represents vulcanised rubber?

A I B II C III D IV

E-50
42
C

The percentage by mass of silicon in the compound $(CH_3)_2Si(OH)_2$ is 30·5 %. This compound polymerises, forming a silicone polymer. The percentage by mass of silicon in the polymer would be

A 30·5 %.
B less than 30·5 %.
C more than 30·5 %.
D either A, B or C, depending upon the degree of polymerisation.

E-51
42
C

A cross linked silicon polymer can be prepared by adding water to a mixture of $(CH_3)_3SiCl$, $(CH_3)_2SiCl_2$ and CH_3SiCl_3.

The amount of cross linking in the polymer is increased by increasing the proportion of

A $(CH_3)_3SiCl$.
B $(CH_3)_2SiCl_2$.
C CH_3SiCl_3.
D water.

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E-52
50
B

If the chlorosilanes $(C_2H_5)_3SiCl$ and $(C_2H_5)_2SiCl_2$ were mixed and hydrolysed, the relative molecular mass of the polymer produced would be greatest if

A the amount of $(C_2H_5)_3SiCl$ were greater than the amount of $(C_2H_5)_2SiCl_2$.
B the amount of $(C_2H_5)_3SiCl$ were less than the amount of $(C_2H_5)_2SiCl_2$.
C the amounts of $(C_2H_5)_3SiCl$ and $(C_2H_5)_2SiCl_2$ were equal.

E-53
50
D

Methyl hydroxysilanes readily undergo condensation reactions to form polymers. Which of the following molecules is most likely to cause termination of a linear polymer chain in such a reaction?

A $Si(OH)_4$
B $CH_3Si(OH)_3$
C $(CH_3)_2Si(OH)_2$
D $(CH_3)_3SiOH$

E-54
31
C

Under conditions when hydrolysis and subsequent condensation reactions could be expected to occur, the chlorosilane $(CH_3)_3SiCl$ will probably

A form the linear polymer $\{-(CH_3)_2Si-O-Si(CH_3)_2-O-\}_n$.
B form a cross linked silicone resin.
C form the dimer $(CH_3)_3Si-O-Si(CH_3)_3$.
D not react.

E-55
39
C

The types of reaction occurring in the production of silicones from chlorosilanes are, in order,

A addition, condensation.
B substitution, addition.
C substitution, condensation.
D hydrolysis, addition.

E-56
35
A

A silicone grease is best described as a

A linear polymer mixed with an inert filler.
B polymer containing cross links every 1 000 atoms.
C polymer containing cross links every 100 atoms.
D polymer in which every silicon atom participates in cross linking.

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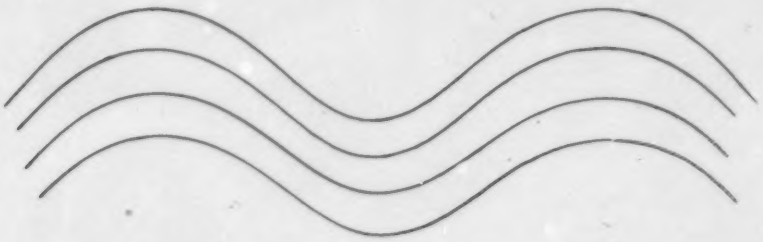
The next two items refer to the following information

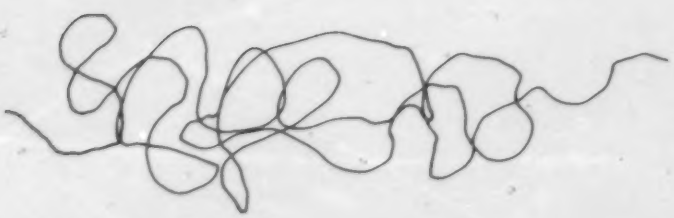
The diagrams below represent the structures of various types of polymers.

I

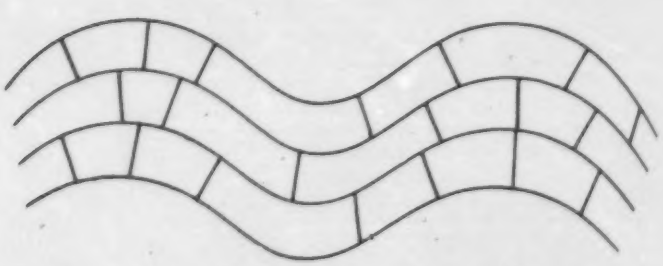


II

III



IV



E-57 60 A The structure of high density poly(ethylene) is best represented by

A I. B II. C III. D IV.

E-58 68 D The structure of a silicone resin is best represented by

A I. B II. C III. D IV.

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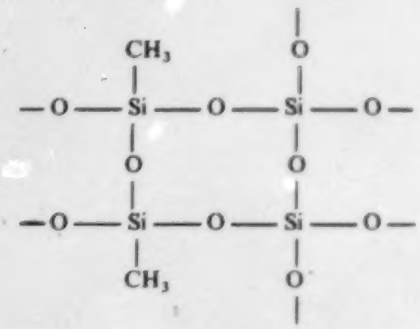
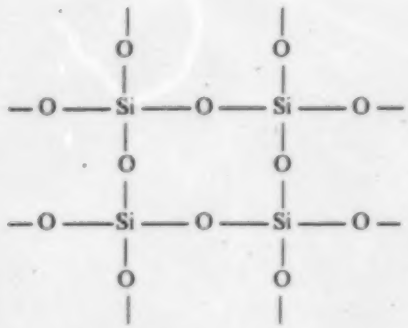
E-59
54
A

Which one of the following formulae best represents the structure of a silicone sealant after prolonged exposure to the air?

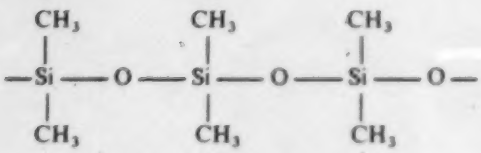
A



C



B



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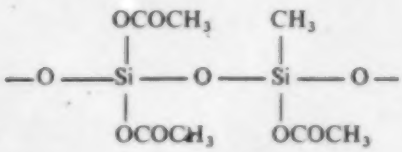

E-60
57
B

The odour of acetic acid is detected during the hardening of the liquid from a tube of a common silicone sealant.

The liquid in the tube probably consists of a

A solution of a cross linked polymer in acetic acid.
B linear polymer with acetate side groups.
C polymer cross linked by acetate groups.
D solution of a cross linked polymer in water.

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UNIT F

From minerals to metals

F-1 75 **D**

Which of the following factors could be important in determining if a mineral deposit is an ore body?

A geographical location of the mineral deposit
B concentration of metal in the mineral deposit
C selling price of the metal
D all of the above

F-2 81 **B**

Which of the following metals is **not** usually found as an oxide ore in nature?

A iron
B calcium
C aluminium
D uranium

F-3 26 **B**

Which of the following procedures could **not** be used to convert iron ore to iron?

A electrolysis of the molten ore
B passage of CO_2 gas over the ore at high temperatures
C passage of H_2 gas over the ore at high temperatures
D heating a mixture of carbon and iron ore

F-4 74 **B**

Small quantities of metal can be extracted from some oxides using a charcoal block, a Bunsen burner and a blowpipe. The extraction of iron by this method occurs at temperatures below the melting temperature of iron.

The product is best described as

A pig iron.
B sponge iron.
C wrought iron.
D cast iron.

F-5 89 **B**

Wrought iron may be prepared from sponge iron by

A heating in the presence of coke.
B rolling at high temperatures.
C alloying with controlled quantities of other metals.
D blowing pure CO on the surface of the molten metal.

F-6 72 **C**

Compared to pig iron, wrought iron has a

A higher carbon content and is more ductile.
B higher carbon content and is less ductile.
C lower carbon content and is more ductile.
D lower carbon content and is less ductile.

F-7 60 **D**

Cast iron is a type of

A sponge iron.
B wrought iron.
C steel.
D pig iron.

F-8 64 **C**

Iron ore is admitted at the top of a blast furnace. Which of the following must also be added to ensure the successful operation of the furnace?

A limestone and sand
B sand and coke
C limestone and coke
D limestone, sand and coke

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F-9 49 A

Coke has several functions in the blast furnace. Which of the following is **not** one of its functions?

A forming a slag with impurities
B keeping the contents of the furnace porous
C acting as a reductant
D acting as a source of heat when oxidized

F-10 54 A

The material(s) specifically added to the blast furnace charge in order to form a slag is (are)

A limestone.
B sand.
C limestone and coke.
D limestone and sand.
E limestone, sand and coke.

F-11 60 A

Which one of the following reactions is **least** likely to occur in a blast furnace?

A $3FeO + CO_2 \rightarrow Fe_3O_4 + CO$
B $3Fe_2O_3 + CO \rightarrow 2Fe_3O_4 + CO_2$
C $CaCO_3 \rightarrow CaO + CO_2$
D $C + CO_2 \rightarrow 2CO$

F-12 70 D

The chemical changes occurring to iron in a blast furnace and to impurities in iron in a steel making furnace may be classified as, respectively,

A oxidation and oxidation.
B oxidation and reduction.
C reduction and reduction.
D reduction and oxidation.

F-13 81 A

Which of the following statements best describes the reaction conditions employed in iron making and steel making?

A Reducing conditions are used in iron making and oxidizing conditions are used in steel making.
B Oxidizing conditions are used in iron making and reducing conditions are used in steel making.
C Reducing conditions are used in both iron making and steel making.
D Oxidizing conditions are used in both iron making and steel making.

F-14 17 B

Which of the lists below gives wrought iron, pig iron and steel in order of increasing carbon content?

A wrought iron, pig iron, steel
B wrought iron, steel, pig iron
C steel, wrought iron, pig iron
D steel, pig iron, wrought iron
E pig iron, wrought iron, steel
F pig iron, steel, wrought iron

F-15 52 C

An integrated steelworks is **defined** as a steelworks in which

A there is a minimal loss of energy throughout the plant.
B the steel furnace is fed directly from the blast furnace.
C pig iron extraction, steel making and shaping operations are performed.
D the raw materials used are mined in the local area.

F-16 58 A

Electrostatic precipitators are used in integrated steelworks in order to

A collect small particles of iron oxide in exhaust gases.
B reduce the emissions of sulfur dioxide to the atmosphere.
C remove finely divided particles from contaminated water.
D condense steam generated in the coke ovens during quenching.
E precipitate exhaust gases from the blast furnace.

F-17 76 D

One stage in the production of metals from their ores is known as mineral dressing. The purpose of mineral dressing is

A to increase the surface area of the mineral particles in order to make reduction to the metal easier.
B the flotation and collection of the insoluble impurities that occur with the mineral.
C aeration of the crushed ore in order to convert the sulfides into oxides for easier reduction.
D the concentration of a mineral by its separation from other minerals and worthless material.

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F-18 75 **A**

The process of mineral dressing involves

A sorting of minerals from other material.
B conversion of metal sulfides to the metal oxide.
C formation of a slag to remove impurities.
D extraction of a metal from a mineral.

F-19 90 **C**

In the process of froth flotation using xanthate as a collector, mineral particles become

A water attracting by adsorption of xanthate ions.
B water attracting by adsorption of a frother.
C water repellent by adsorption of xanthate ions.
D water repellent by adsorption of a frother.

F-20 56 **B**

Kerosene will act as a collector for some minerals, but xanthates are used in industry. One reason for this is because kerosene

A is non polar and is insoluble in water.
B does not selectively collect mineral particles.
C does not produce a stable head of froth.
D will only float particles of a certain size.

F-21 81 **C**

Which of the following minerals is most likely to be separated from impurities by flotation using a xanthate as a collector?

A silica (SiO_2)
B malachite ($Cu_3(OH)_2(CO_3)_2$)
C galena (PbS)
D cassiterite (SnO_2)

F-22 70 **B**

The first stage in the extraction of copper from its sulfide ores is usually to

A roast the ore in the presence of air.
B concentrate the ore by flotation.
C melt the ore in the presence of silica.
D dissolve the ore in sulfuric acid solution.

F-23 80 **A**

Mineral concentrates containing metal sulfides are usually roasted. In this process the concentrates are heated in the presence of

A air.
B pure hydrogen sulfide.
C carbon dioxide.
D carbon monoxide.

F-24 75 **B**

Sulfide ores are usually roasted before the ore is reduced with carbon or hydrogen. This is mainly because

A any sulfur present in the ore would react to form the toxic gases CS_2 or H_2S.
B sulfides cannot be effectively reduced by carbon or hydrogen.
C SO_2 produced is needed to manufacture sulfuric acid used in the process.
D all metal in the ore must have the same oxidation number for efficient processing.

F-25 64 **B**

The first stage of convential copper smelting is to roast the concentrate in air. The product is called

A matte.
B calcines.
C blister copper.
D slag.

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F-26
58
A

The copper concentrate obtained from flotation often contains about 30 % iron in the form of an iron sulfide. The majority of the iron is removed in conventional smelting by

A formation of iron oxide and extraction in a slag.
B reduction using carbon monoxide and separation in a slag.
C separation of the liquid iron and copper phases.
D electrolytic refining of the impure copper metal.
E oxidation and separation by solvent extraction.

F-27
67
A

In the conventional smelting of copper, copper matte is transferred to a converter vessel where iron impurities are separated and removed in a slag. An important reason why iron separates from the copper in the converter is the greater affinity of

A iron for oxygen.
B copper for oxygen.
C iron for sulfur.
D copper for sulfur.

F-28
44
D

Silica is used as a purifying agent in the conventional copper smelting process. It is mainly used to remove

A aluminium.
B sulfur.
C phosphorus.
D iron.

F-29
53
E

During conventional copper smelting, copper matte is transferred from the reverberatory furnace to the converter. The final product from the converter is mainly

A Cu_2S. B Cu_20. C CuS. D Cu0. E Cu.

F-30
29
A

Wooden poles are often used to stir molten copper during the refining process. They are employed mainly because

A gases distilled from the poles reduce any copper oxide present.
B most common metals would melt in the high temperature conditions.
C the low thermal conductivity of wood permits stirring to be done manually.
D alloys are formed if other metals are present.

F-31
45
D

Which one of the following processes does **not** usually occur in the pyrometallurgical production of copper from a sulfide ore?

A Silica is added to the calcines to produce slag.
B Iron reacts preferentially with oxygen in the converter.
C Cu_2S is reduced to copper metal in an air blow.
D Copper oxides are roasted in air.

F-32
80
D

The major pollutant from copper smelters is

A CO_2 gas.
B CO gas.
C copper oxide dust.
D SO_2 gas.
E H_2S gas.

F-33
44
E

A gas which would be a suitable raw material for a sulfuric acid plant is most likely to be obtained from a

A blast furnace.
B flotation cell.
C electrowinning cell.
D steel making furnace.
E copper smelter.

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F-34
26
A

Trace metal impurities present in the 'fire refined copper' produced in copper smelters may be removed by electrorefining.

During this process, metals that are more easily

A oxidized than copper will dissolve into solution.
B oxidized than copper will be deposited on the anode.
C reduced than copper will be deposited on the cathode.
D oxidized than copper will fall to the bottom of the cell.

F-35
38
D

Which of the following metals is most likely to be found in the mud at the bottom of an electrolysis cell used for electrorefining copper?

A iron
B zinc
C nickel
D gold

F-36
73
D

Which of the lists below names processes used in hydrometallurgical extraction of copper in the sequence in which they are employed?

A solvent extraction, electrolysis, leaching
B solvent extraction, leaching, electrolysis
C leaching, electrolysis, solvent extraction
D leaching, solvent extraction, electrolysis

F-37
60
C

Leaching is a process employed in hydrometallurgical plants in which

A a metal ion is selectively precipitated by the formation of a metal complex.
B metal ions are separated on the basis of their different solubilities in organic liquids.
C a solution is prepared containing the metal ion to be recovered.
D selective separation of the metal ions in a solution is achieved by adjusting pH.

F-38
76
C

Ammonia solutions can be used successfully to leach copper(II) oxide because

A ammonia reacts with impurities in the solution.
B ammonia solutions contain the strong leaching ion, NH_4^+.
C ammonia forms a complex with copper ions.
D the pH of the solution prevents precipitation of copper metal.

F-39
48
B

Which of the following **must** be a property of organic liquids used to purify solutions of metal ions by solvent extraction?

A They have a lower density than water.
B They do not dissolve in water.
C They have a higher density than water.
D They are more polar than water.

F-40
64
D

Naphthenic acid extracts metal ions from aqueous solution because

A the ions participate in hydrogen bonding with the acid molecules.
B metal ions dissolve readily in non-polar solvents.
C the ions form ion-dipole bonds with neighbouring acid molecules.
D the ions form weak bonds with naphthenate anions.

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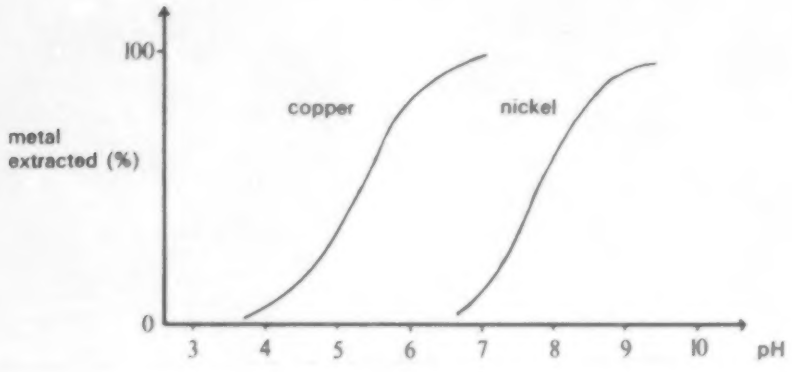
The next two items refer to the following information

The amount of metal extracted from an aqueous phase into naphthenic acid depends upon the pH of the aqueous phase. The graph below illustrates this relationship for copper and nickel.



F-41 92 **B** In order to **selectively** extract most of the copper ions from a solution containing copper and nickel ions into naphthenic acid, the pH of the solution should be

A 3. **B** 6. **C** 8. **D** 10.

F-42 76 **B** Copper ions extracted into naphthenic acid could be removed by addition of

A 1M sodium hydroxide solution.
B 1M sulfuric acid.
C 1M copper(II) sulfate solution.
D water.
E kerosene.

F-43 40 **D** Copper metal may be extracted from its ores by electrowinning. In this process, the ore is dissolved in sulfuric acid and the solution is electrolysed using electrodes made from lead and copper. Which of the following would be the major product formed at the anode?

A copper metal
B Cu^{2+} ions
C hydrogen gas
D oxygen gas
E Pb^{2+} ions

F-44 57 **D** The process of electrowinning involves electrolytic

A purification of a piece of impure metal, which acts as an anode in a cell.
B purification of a piece of impure metal, which acts as a cathode in a cell.
C deposition of metal ions from solution on an anode in a cell.
D deposition of metal ions from solution on a cathode in a cell.

F-45 39 **B** If Fe^{2+} ions are present in solution during electrolytic winning of copper, the current efficiency is reduced. This is because the

A Fe^{2+} is reduced to iron metal at the anode of the cell.
B Fe^{2+} is oxidized to Fe^{3+} at one electrode and Fe^{3+} is reduced to Fe^{2+} at the other.
C Fe^{2+} is reduced to iron metal at the cathode of the cell.
D Fe^{2+} ions reduce Cu^{2+} to copper metal which is deposited at the bottom of the cell.
E Fe^{2+} is reduced to iron metal at one electrode and oxidized to Fe^{3+} at the other.

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F-46 30 D

In the electrolytic zinc process, as used in Tasmania and South Australia, the majority of the impurities are removed from the roasted concentrate by

A addition of silica to the molten material.
B injection of air in a reverberatory furnace.
C electrolysis of a solution of the material.
D precipitation from a solution of the material.

F-47 69 C

If m_1 is the mass of a metal obtained by electrolysis and m_2 is the mass expected on the basis of Faraday's Law, the current efficiency is the ratio

A $\frac{m_2}{m_1} \times 100.$
B $\frac{m_2 - m_1}{m_2} \times 100.$
C $\frac{m_1}{m_2} \times 100.$
D $\frac{m_2 - m_1}{m_1} \times 100.$

F-48 33 A

A current of 1·1 A is passed through a cell containing a solution of zinc(II) sulfate for 1 hour. If 0·90 g of metal were deposited, the current efficiency would be (given $F = 96487$ C mol^{-1}; A_r Zn = 65·4)

A $\frac{96487 \times 2 \times 0{\cdot}90 \times 100}{1{\cdot}1 \times 60 \times 60 \times 65{\cdot}4}$ %.
B $\frac{96487 \times 0{\cdot}90 \times 100}{1{\cdot}1 \times 60 \times 60 \times 2 \times 65{\cdot}4}$ %.
C $\frac{1{\cdot}1 \times 60 \times 60 \times 0{\cdot}90 \times 100}{96487 \times 65{\cdot}4}$ %.
D $\frac{96487 \times 0{\cdot}90 \times 100}{1{\cdot}1 \times 60 \times 60 \times 65{\cdot}4}$ %.
E $\frac{1{\cdot}1 \times 60 \times 60 \times 65{\cdot}4 \times 100}{96487 \times 2 \times 0{\cdot}90}$ %.

F-49 26 B

The most abundant metal in the earth's crust is

A copper.
B aluminium.
C zinc.
D iron.

F-50 79 B

Which of the following metal oxides could **not** be reduced to the metal using a blowpipe, Bunsen flame and charcoal block?

A Fe_2O_3 B Al_2O_3 C PbO D CuO

F-51 32 C

Which of the following does **not** usually occur during the electrochemical extraction of aluminium metal?

A CO_2 is produced at the positive electrode.
B Alumina is dissolved in molten Na_3AlF_6.
C The cathode material is consumed and replaced at frequent intervals.
D Liquid aluminium is drawn off from the bottom of the cell.

F-52 36 C

The major gaseous product from an aluminium cell is

A HF. B O_2. C CO_2. D F_2.

F-53 40 C

An electrolysis cell used for aluminium production is usually constructed with a

A steel mesh cathode and a carbon anode.
B carbon cathode and a steel mesh anode.
C carbon cathode and a carbon anode.
D carbon cathode and a lead anode.
E lead cathode and a carbon anode.

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F-54 52 **B**

The anodes in the cells used for electrolytic extraction of aluminium from alumina are moveable. This is because

A overheating can occur due to the high current densities employed.
B the electrodes must be fed into the electrolyte since they are consumed during the electrolysis.
C it is essential to move the electrodes into regions where the anions tend to concentrate.
D the movement of electrodes is essential to break up the electrolytic crust of solid cryolite.
E the motion of the electrolyte lowers the overpotential for graphite electrodes in the cell.

F-55 52 **D**

Aluminium ($A_r = 27{\cdot}0$) is manufactured by the electrolysis of Al_2O_3 dissolved in melted cryolite. The reactions at the electrodes are:

$$Al_2O_3 + 6e^- \rightarrow 2Al + 3O^{2-}$$
$$C + 2O^{2-} \rightarrow CO_2 + 4e^-$$

What mass of aluminium would be expected from a cell operating at a current of 13000 A for 5 minutes (given $F = 96\,487$ C mol^{-1})?

A $\dfrac{13000 \times 5 \times 60 \times 3 \times 27{\cdot}0}{96487}$ g.

B $\dfrac{96487 \times 3}{13000 \times 5 \times 60 \times 27{\cdot}0}$ g.

C $\dfrac{13000 \times 5 \times 60 \times 96487 \times 27{\cdot}0}{3}$ g.

D $\dfrac{13000 \times 5 \times 60 \times 27{\cdot}0}{96487 \times 3}$ g.

E $\dfrac{13000 \times 5 \times 60 \times 27{\cdot}0}{96487}$ g.

F-56 34 **C**

The fluoride ion is a potential pollutant from aluminium smelters. The major source of the fluoride ion is the

A F_2 gas used to reduce Al^{3+} ions to the metal.
B F^- impurity in alumina used in electrolysis cells.
C AlF_6^{3-} ions in the material used to dissolve alumina.
D F^- present in water used to quench the molten metal.

F-57 81 **D**

Uranium ore is often concentrated close to the mine site and shipped in a form called 'yellow cake'. The approximate composition of yellow cake is

A UO_2. **B** UO_3. **C** U_2O_3. **D** U_3O_8.

F-58 44 **A**

The final stage in the isolation of uranium metal from uranium ore usually involves reduction of UF_4 with

A magnesium. **B** carbon. **C** carbon monoxide. **D** hydrogen. **E** manganese(IV) oxide.

F-59 24 **C**

Which of the following procedures is part of the usual process used to extract uranium metal?

A extraction of impurities in a slag
B selective flotation of ore using sodium ethyl xanthate
C roasting followed by leaching with sulfuric acid
D high temperature reduction of yellow cake with carbon monoxide
E electrolytic precipitation of metal ions in ammonia solution

F-60 71 **A**

Control of water pollution is easier in pyrometallurgical plants than in hydrometallurgical plants. This is because

A the water in pyrometallurgical plants is mainly used for cooling and contamination is small.
B contaminants in water from pyrometallurgical plants tend to be heavy metals and are more easily precipitated.
C impurities tend to be concentrated by the recycling processes used in hydrometallurgical plants.
D the presence of organic liquids in water from hydrometallurgical plants causes high concentrations of metal ions.

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